SOILVISION™

A Knowledge-Based Soils Database

Tutorial Manual

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Written by:
Gordon Hundeby, B.Sc.M.E.
Murray Fredlund, Ph.D.

Edited by:
Murray Fredlund, Ph.D.

SoilVision Systems Ltd.
Saskatoon, Saskatchewan, Canada

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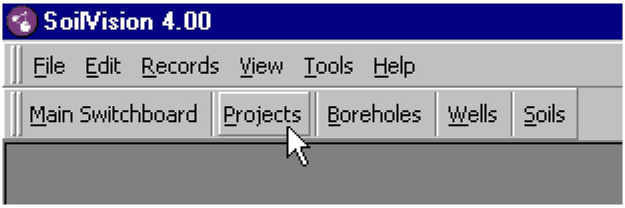
1 ENTERING NEW DATA

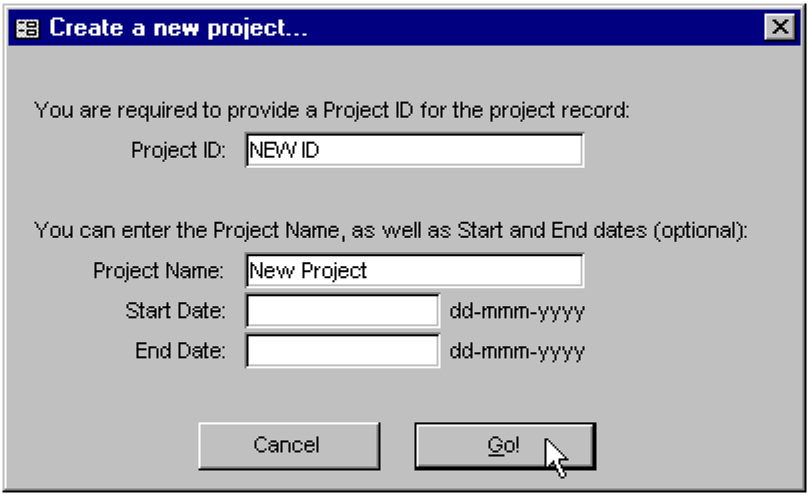
The following sections outline how to enter new data into various fields of the SoilVision database. For the entry of new data, the user should have opened the SVSoils_MyData database distributed by SoilVision. The SVSoils_MyData database is a blank database designed for the storage of user-specified data. Details on how to open the SVSoils_MyData database may be found in the SoilVision User's Manual.

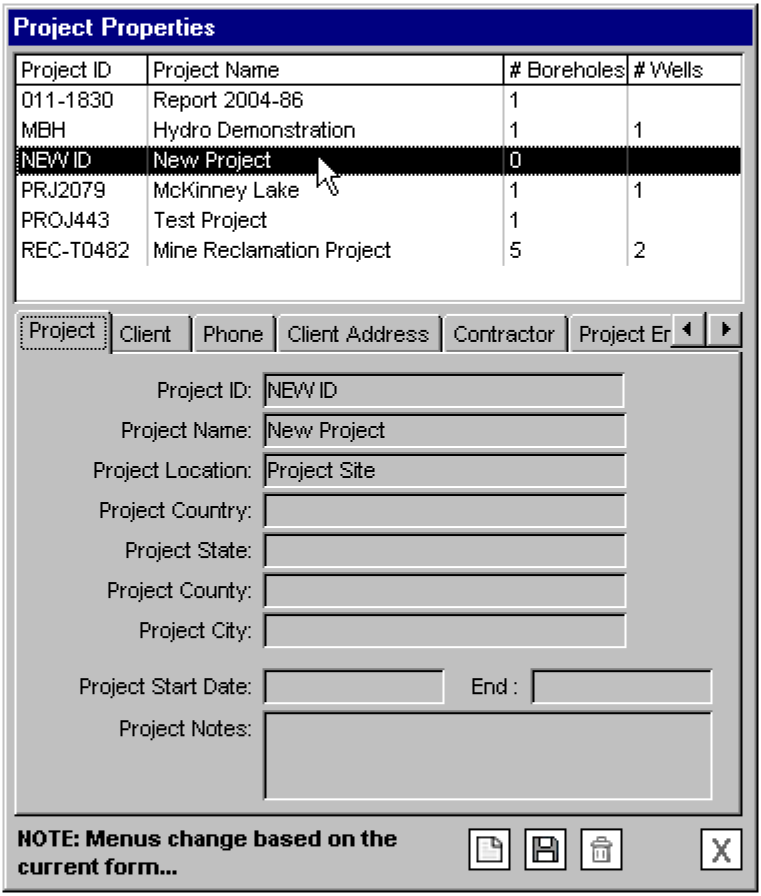
1.1 PROJECT INFORMATION

SoilVision requires that each borehole and soil entered into the database be organized under a project. The **Projects** form can be accessed by clicking the **Projects** button on the main tool bar as shown below.



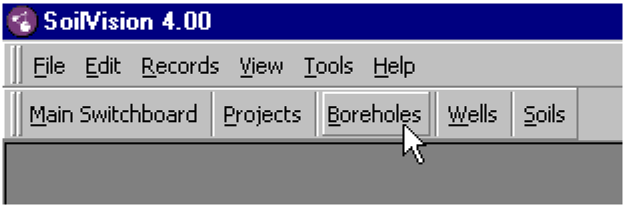
Data may be entered in the **Projects** form by clicking on one of the tabs (Project, Client, etc.) on the form. It should be noted that once the project is defined, it will be identified by the Project ID throughout the rest of the program. Also, SoilVision does not allow you to specify two projects with the same Project ID. A new project dialog box is provided to assist you in adding a new project (shown below). Click the new project icon to bring up this dialog box. After the new project is created, you may add to or edit the project properties. You should enter at least the information listed under Recommended Minimum Input.

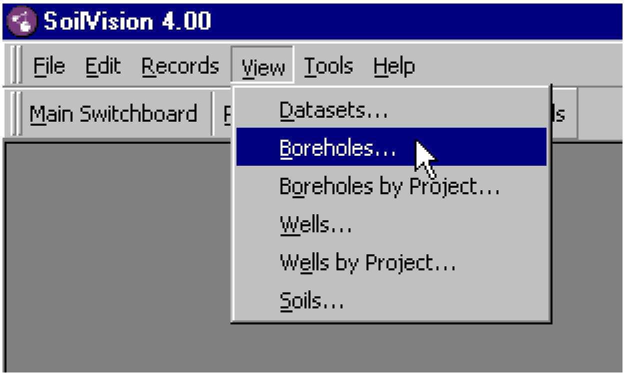

Create a new project...
You are required to provide a Project ID for the project record:
Project ID:
NEW ID
You can enter the Project Name, as well as Start and End dates (optional):
Project Name:
New Project
Start Date:
dd-mmm-yyyy
End Date:
dd-mmm-yyyy
Cancel
Go!


Project Properties
Project ID
Project Name
Boreholes
Wells
011-1830 Report 2004-86 1
MBH Hydro Demonstration 1 1
NEW ID New Project 0
PRJ2079 McKinney Lake 1 1
PROJ443 Test Project 1
REC-T0482 Mine Reclamation Project 5 2
Project
Client
Phone
Client Address
Contractor
Project Er
Project ID:
NEW ID
Project Name:
New Project
Project Location:
Project Site
Project Country:
Project State:
Project County:
Project City:
Project Start Date:
End :
Project Notes:
NOTE: Menus change based on the current form...

Recommended Minimum Input
Project ID
Project Name
Project Location

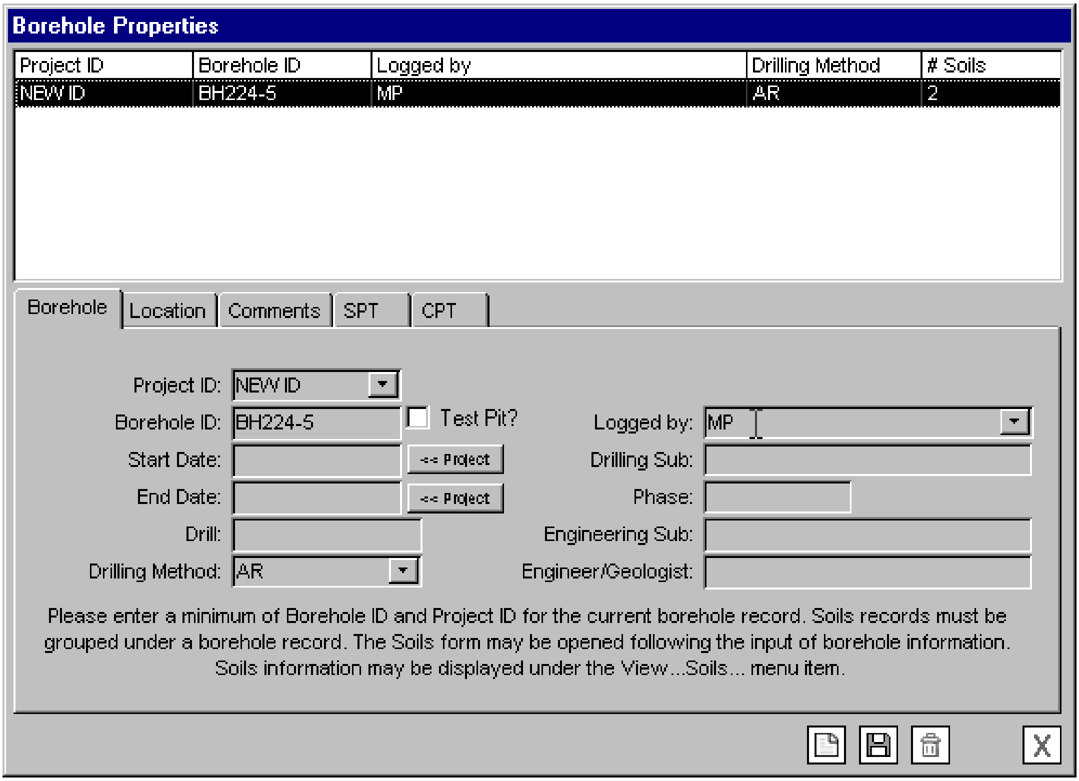
After sufficient data has been entered to meet or exceed the minimum requirements, (see Recommended Minimum Input) the data will be saved when clicking the save icon or when exiting the form or proceeding to the **Boreholes** form. There are three ways to access and input borehole information in SoilVision. The first is to click the **Boreholes** button on the main toolbar. The second is to click the **Boreholes…** command in the **View** menu. Both methods are illustrated below. The third is to double-click on the desired project, which will show the boreholes it contains. Selecting the **Boreholes by Project…** command in the **View** menu will also show the boreholes that the currently selected project contains.





1.2 BOREHOLE INFORMATION

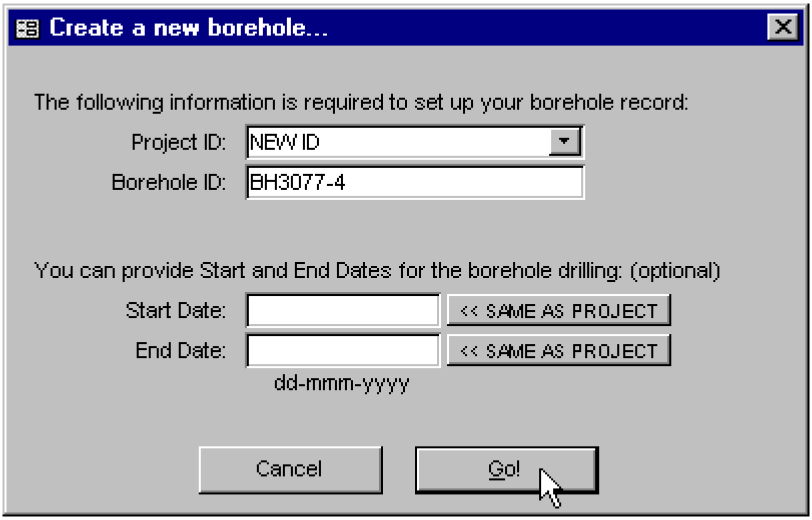
Organizing a borehole under a project is done by selecting a **Project ID** in the **Borehole** form.



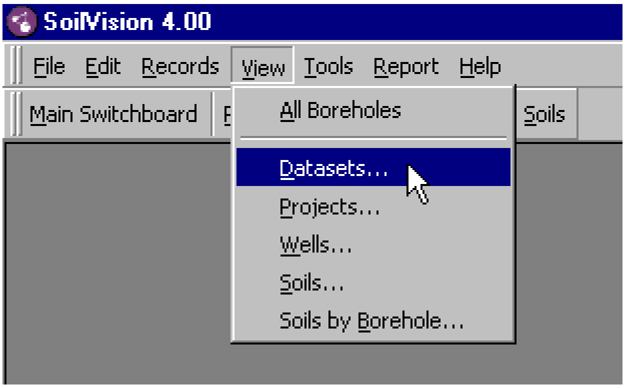
Recommended Minimum Input

Project ID
Borehole ID
Drilling Method

A new borehole dialog box is provided to assist you in adding a new borehole. After a new borehole is created, you may add to or edit the borehole properties. You should enter at least the information listed under Recommended Minimum Input.

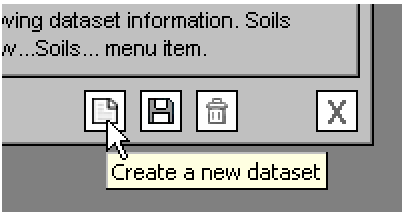


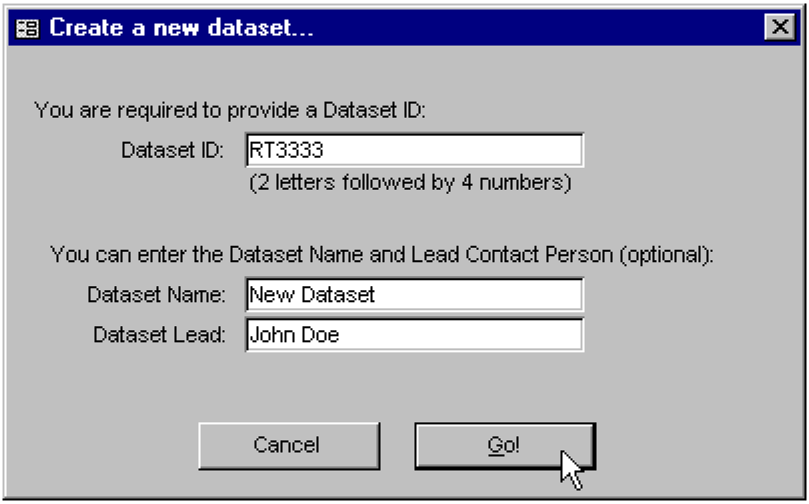
After the Borehole information has been entered, the user may proceed to the **Dataset** form by the method shown below. Entry of at least one dataset record in each database is required by SoilVision.

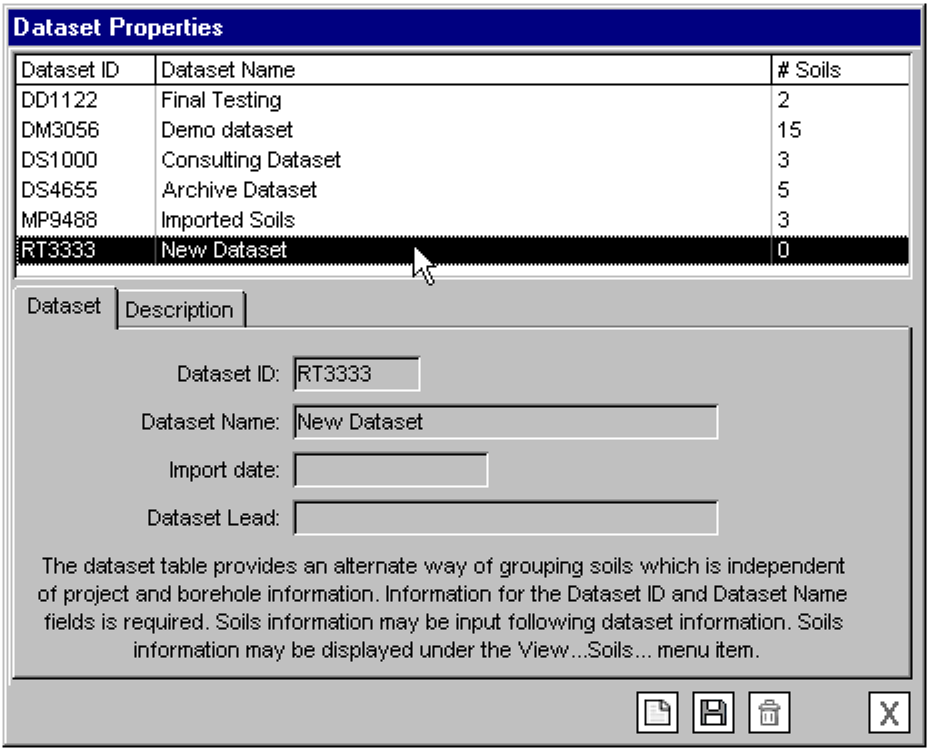


1.3 DATASET INFORMATION

The **Dataset Properties** form contains information in the SoilVision database designed to help organize where the soil sample originated as well as the individual or organization responsible for providing the soil. To enter new data into the **Dataset Information** window the user can click on the fields in either the **Dataset** or **Description** tabs. To create a new dataset, click the new record icon at the bottom of the form, and enter the appropriate data into the new dataset dialog box. Make sure you have entered at least the Minimum Recommended Input.


ving dataset information. Soils
w...Soils... menu item.
X
Create a new dataset

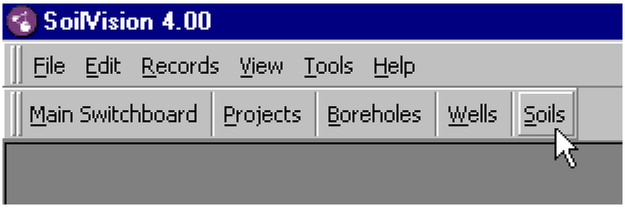

Create a new dataset...
You are required to provide a Dataset ID:
Dataset ID:
RT3333
(2 letters followed by 4 numbers)
You can enter the Dataset Name and Lead Contact Person (optional):
Dataset Name:
New Dataset
Dataset Lead:
John Doe
Cancel
Go!

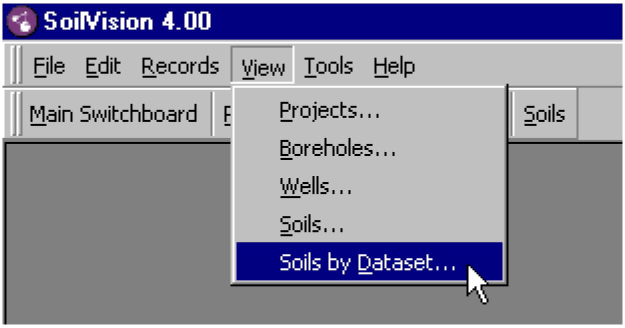


Minimum Recommended Input
Dataset ID
Dataset Name

The only purpose of the Dataset information is to provide an alternate method of organizing soils data. SoilVision enforces that each soil record is organized under a Project and Borehole record. This later allows the user to search by Project ID or Borehole ID. Similarly, having soil data organized under a Dataset ID allows the user to search for a group of soils by Dataset ID. How this may be useful is as follows: Any firm may have all their soils organized under their respective Project ID and Borehole ID. This firm, however, works with two separate testing laboratories (A + B). The firm then creates a separate Dataset ID to represent each testing laboratory. This system then allows the firm to later group together all soils tested by laboratory A even though these soils span multiple Projects.

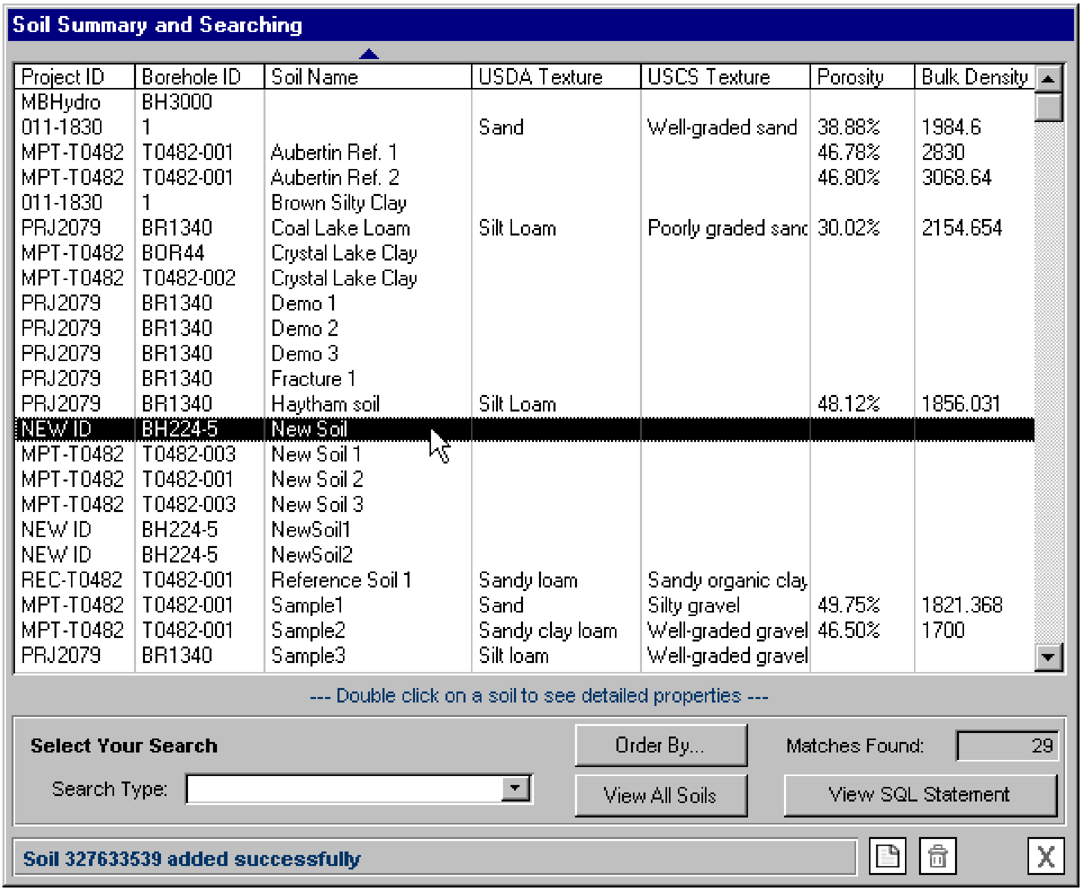
The user may proceed to **Soils** information after completion of entry of dataset information by clicking the **Soils** button on the main toolbar, or by selecting the **View > Soils…** menu option.



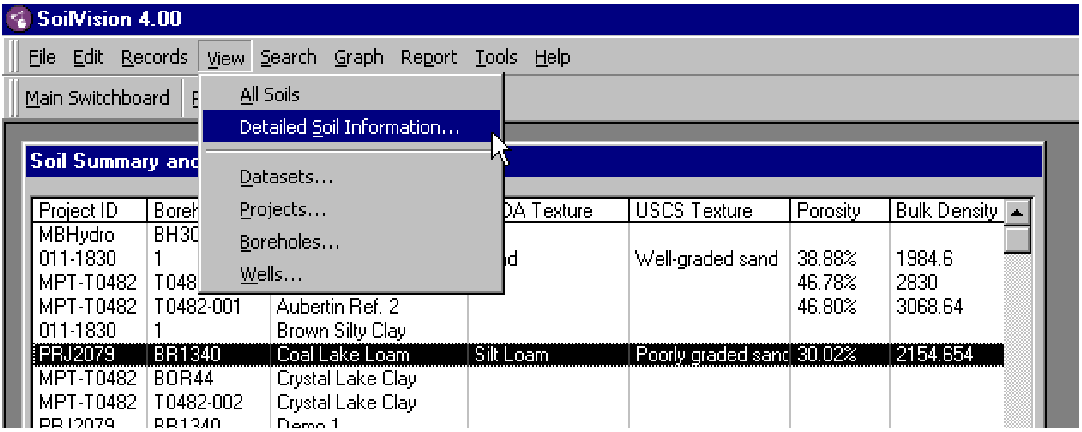


1.4 SOILS INFORMATION

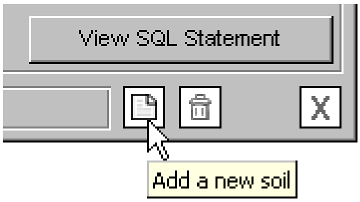
The main **Soil Summary and Searching** form is used in SoilVision for easy browsing and searching of soil records. This form displays a few common soil properties, and allows you to quickly access a number of searches and sorting functions.

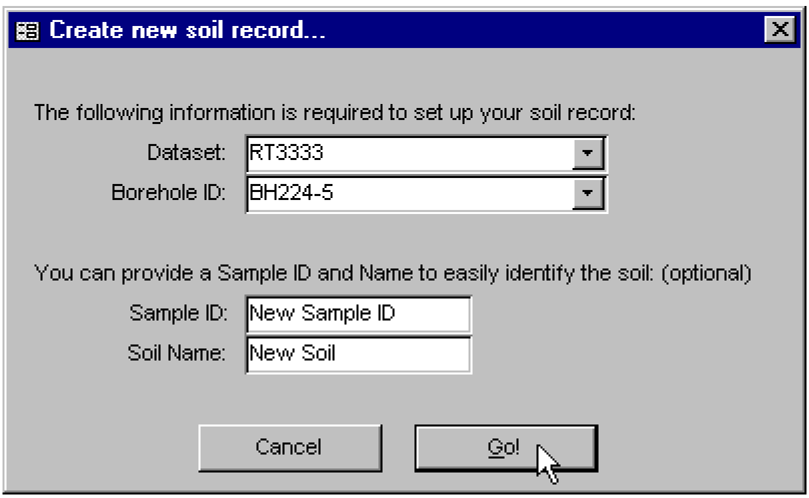


From here you can access any of the previous forms through the methods that have been described, or move on to view detailed soil information, or create a new soil record. To view detailed soil information for an existing soil, either double-click the desired soil or select the desired soil and use the **View > Detailed Soil Information…** menu option.



To create a new record, click the new soil icon at the bottom right of the form, and enter the data requested in the new soil dialog box.

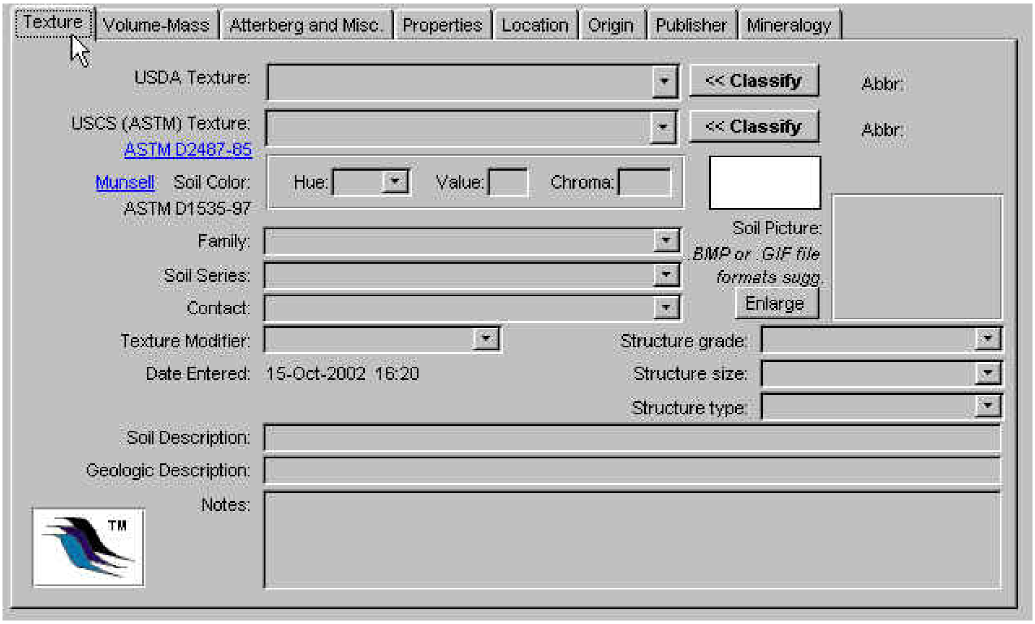




When you access the detailed soil information or add a new soil, the **Soils** form is opened with the specified information, which manages all information about each soil record. The new soil record opens the **Soils** form with the **Texture** tab selected, which is explained in a subsequent section. When creating a new soil record, you should enter information in all fields specified in the Recommended Minimum Input section.

The **Soils** form is used in SoilVision for the managing of general soils data. The most important information to enter will be under the **Texture** and **Volume-Mass** tabs with detailed fields associated with individual soil tests stored in linked tables accessible from the **Properties** tab.

1.4.1 Texture Tab



The texture tab of the **Soils** form provides fields for the description of the soil.

The user can input a variety of information, but should make sure that at least the USDA Texture, USCS Texture, Soil Name, Soil Description, Geological Description, Contact, and Notes fields are filled. While not all of these fields are essential, the more information the user provides will insure the best possible analysis and organization of the particular soil type. It will also aid greatly in the later identification of a particular soil type.

It should be noted that the soil may be automatically classified using the Classify buttons to the right of the fields. Classification will proceed if the minimum data requirements for each classification method are met. The USDA method requires the entry of grain-size information. The USCS method requires entry of grain-size information and Atterberg Limit information.

The USCS (ASTM) classification method is implemented as presented by ASTM D 2487.

The USDA classification method is implemented as presented in the following reference:

Soil Survey Staff. 1975. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. USDA-SCS Agric. Handb. 436. U.S. Gov. Print. Office, Washington, DC.

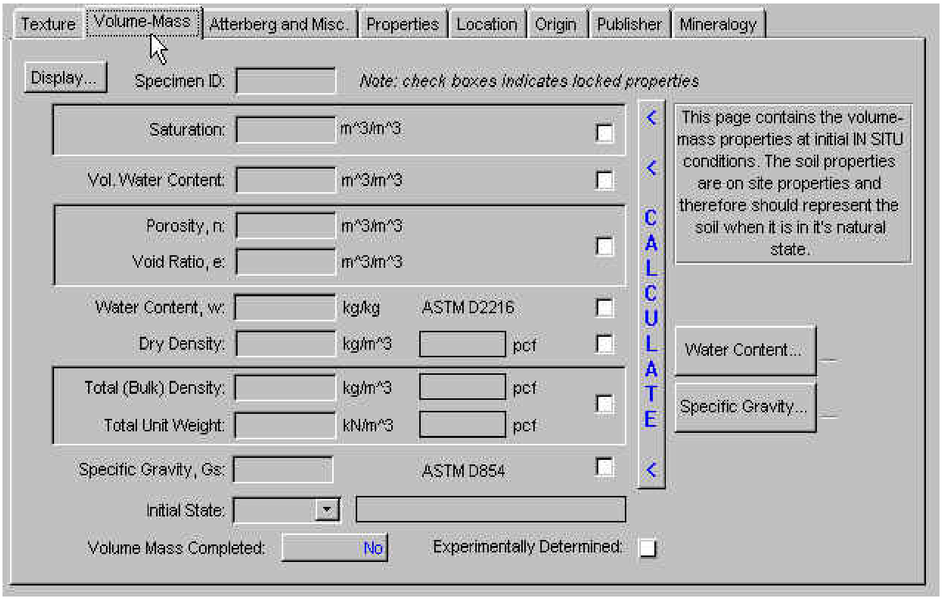
Minimum Recommended Input

USDA Texture

USCS Texture
Contact
Soil Name
Soil Description
Geologic Description
Notes

1.4.2 Volume-Mass Tab

The **Volume-Mass** tab allows for the calculation of basic volume-mass properties. Once any three volume-mass properties are known, the user may "lock" the properties with the adjoining check boxes indicating that the properties were measured and should not be changed by further calculations. The **Calculate** button may then be selected to calculate the remaining volume-mass properties from the three "locked" properties.

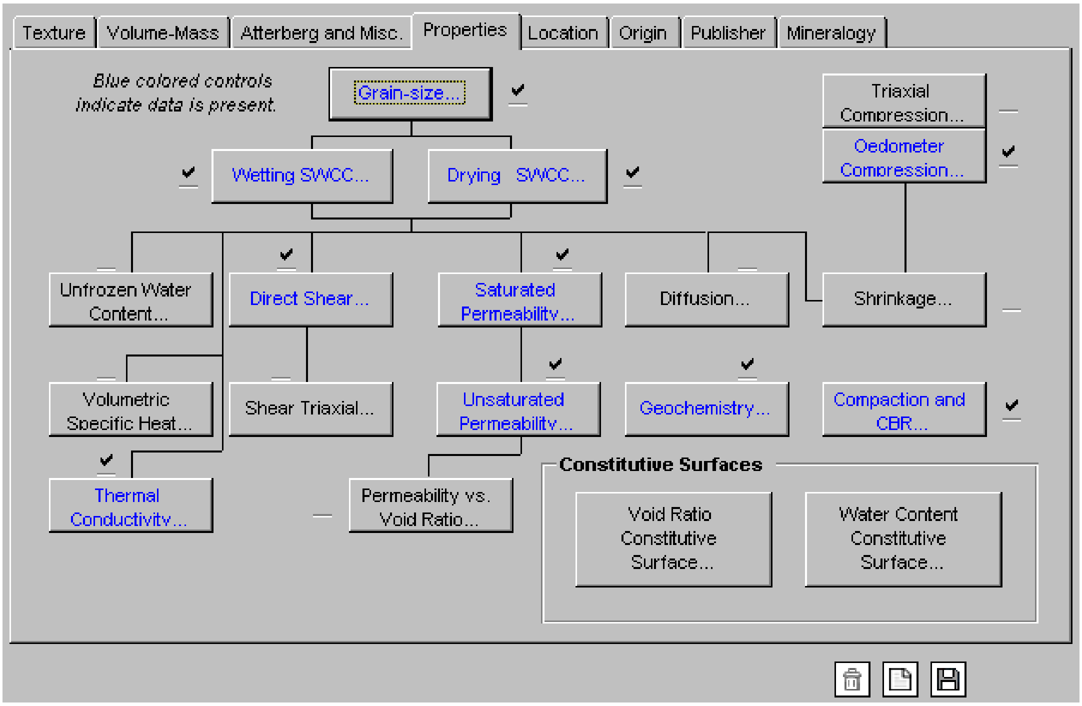


Minimum Recommended Input

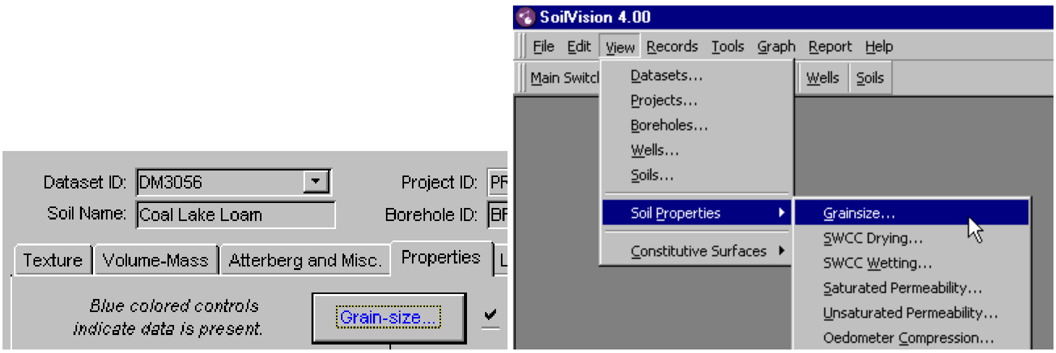
Three or more soil properties
Specimen ID
Initial State

1.4.3 Properties Tab

The **Properties** tab provides links with the various laboratory tests typically performed on a soil. SoilVision will color the text on each respective button the color blue if data is present for the current soil. A check mark will also be displayed beside each respective button if data is present for the specific soil test.



Once the user has viewed the information in the properties tab, they may proceed to **Grain-size Information** by either clicking the **Grain-size** button in the **Properties** tab or by clicking **View > Soil Properties > Grain-size** For this path to work, the **Soils** window must be current. Menus in SoilVision are specific to the form that is current. The menus displayed when the **Grain-size** form is open will be different than the menus displayed when the **Soils** form is current

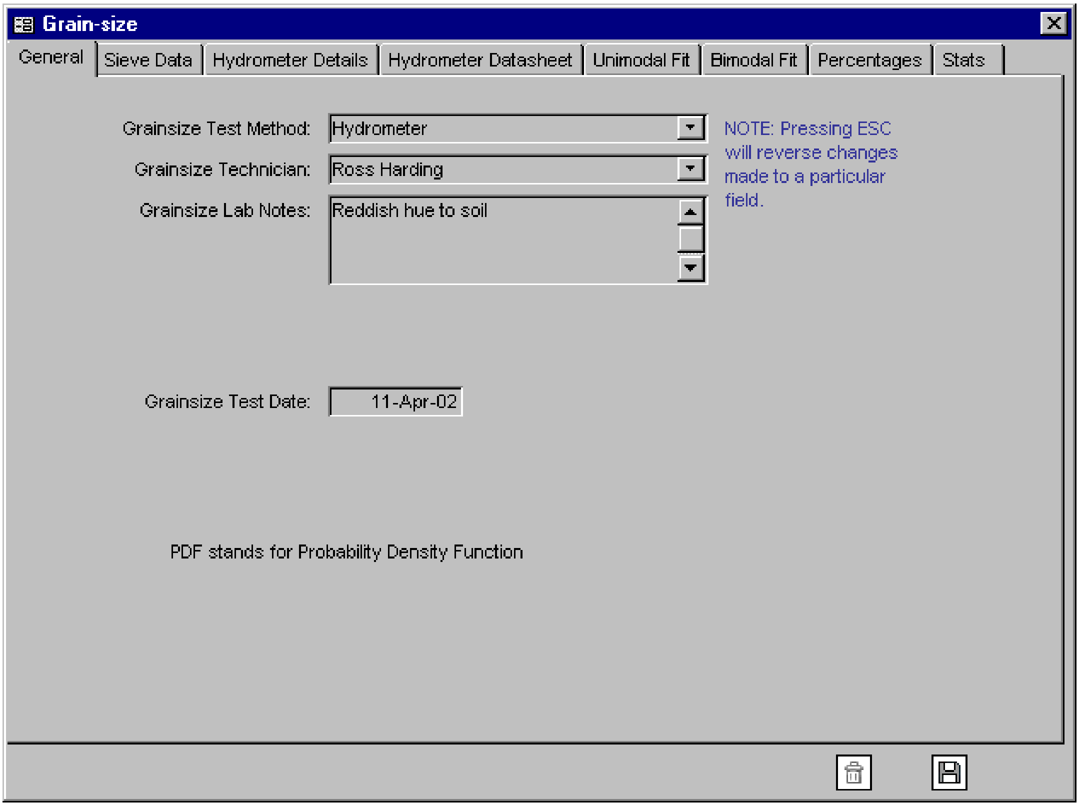


1.5 GRAIN SIZE INFORMATION

The purpose of the **Grain-size** form is to store information related to the particle-size distribution of a soil. The laboratory data for the sieve or hydrometer analysis is stored under the **Sieve Data**, **Hydrometer Details** and **Hydrometer Datasheet** tabs of the **Grain-size** form.

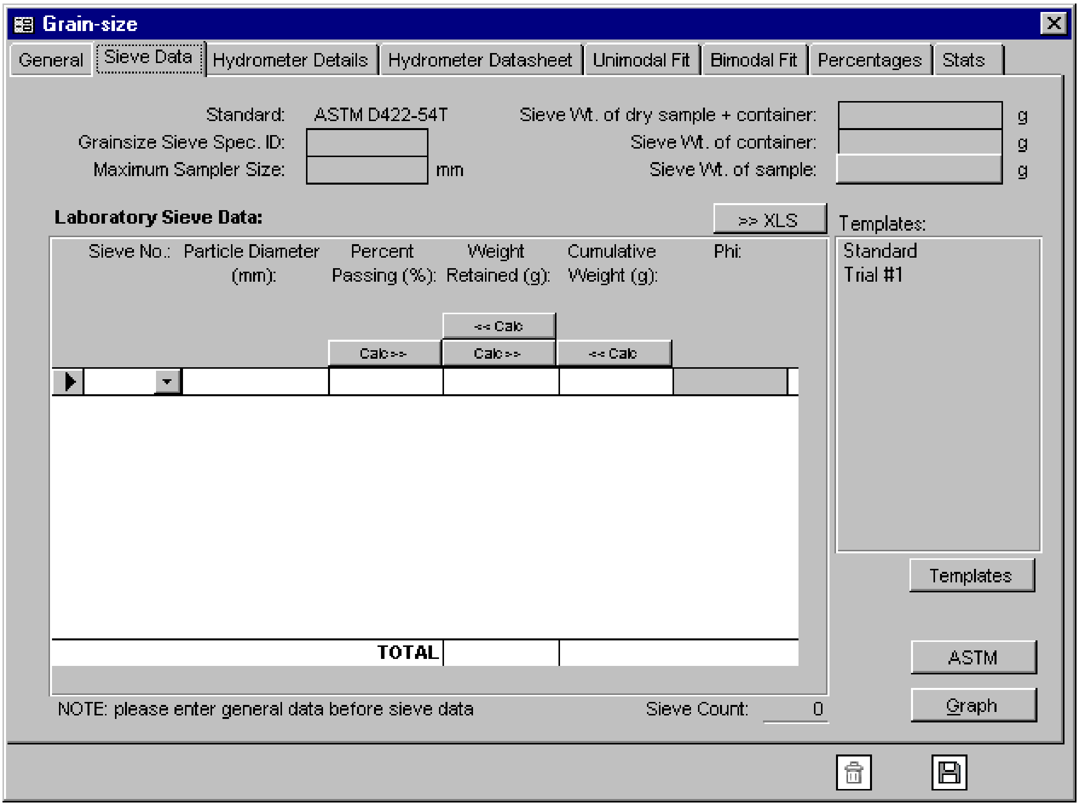
1.5.1 General Tab

The **General** tab contains information such as the technician, test method and laboratory notes which must be entered before sieve or hydrometer data. It should be noted that only the **Test Method** field is essential.



1.5.2 Sieve Data Tab

The **Sieve Data** tab contains all information related to the recording of a sieve analysis on a soil sample. The **Grainsize Sieve Specimen ID** field is provided to uniquely identify the soil specimen. The **Grainsize Sieve Specimen ID** field is optional and is intended to be a subsidiary of the **Sample ID** field contained in the **Soils** form. Sieve data may be entered in terms of particle diameter and percent passing. The **phi** field is then automatically calculated. Calculation of the **Weight Retained** and **Cumulative Weight** columns may be performed by pressing the **>>** or **<<** buttons. Please refer to the SoilVision Theory Manual for a description of the **phi** parameter. Below is a sample of an empty **Sieve Data** form.

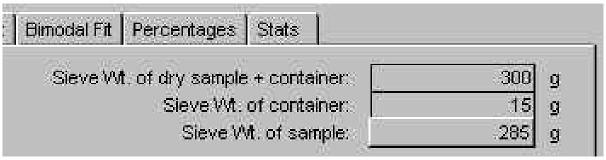


To illustrate the method of data entry into the **Sieve Data** form let us assume that we have performed a sieve test that has yielded the following raw data. It should be noted that the following procedure could be done with **Percent Passing**, **Weight Retained,** or **Cumulative Weight** data.

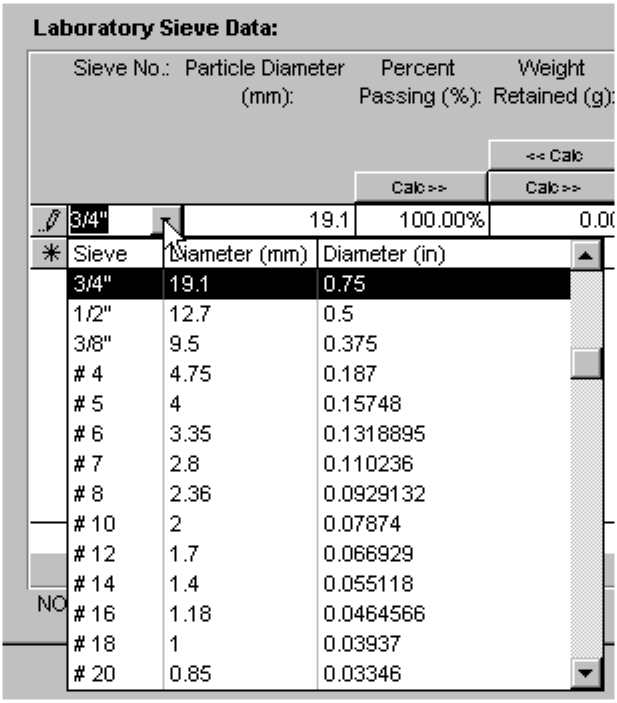
Sieve No.	Percent Passing (%)
3/4"	100.00%
1/2"	84.50%
3/8"	78.80%
# 4	66.90%
# 8	53.10%
# 16	40.30%
# 30	28.40%
# 50	16.40%
# 100	8.20%
# 200	4.50%

Sieve Wt. Of dry sample + container: 300g
Sieve Wt. Of container: 15g

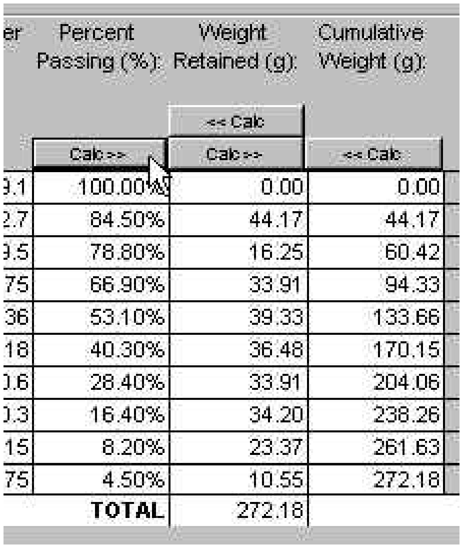
First we enter the **Sieve Wt. of dry sample +container** and the **Sieve Wt. of container** in their respective fields in the upper right of the form. The **Sieve Wt. of container** will automatically be subtracted from the **Sieve Wt. of dry sample +container** to give the **Sieve Wt. of sample**.



Next we input our sieve numbers into the form via the pull down menus in the **Sieve No.** column or by simply entering the sieve size numerically in the field. Note that as you enter each sieve, the corresponding **Particle Diameter** and **Phi** data will automatically appear as well.



We then input the **Percent Passing** data into its appropriate column. When this is finished the weight retained and **Cumulative Weight** columns can be filled by pressing the **Calc>>** or **<<Calc** buttons as shown.

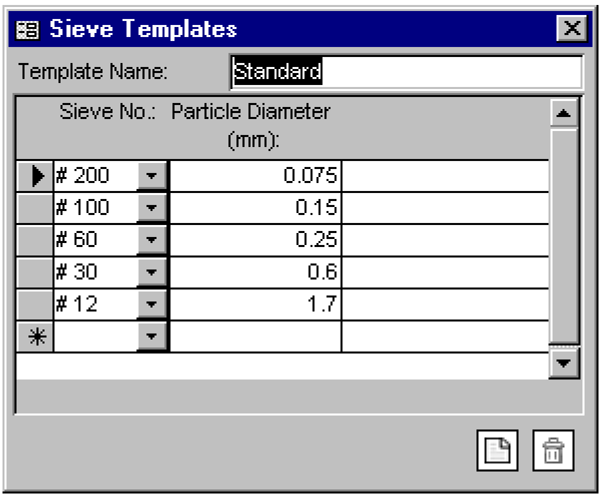


Other buttons on the **Sieve Data form** perform the following functions:

ASTM button opens a form that displays all ASTM defined sieve sizes.

>>XLS button exports the data table as a Microsoft Excel spreadsheet.

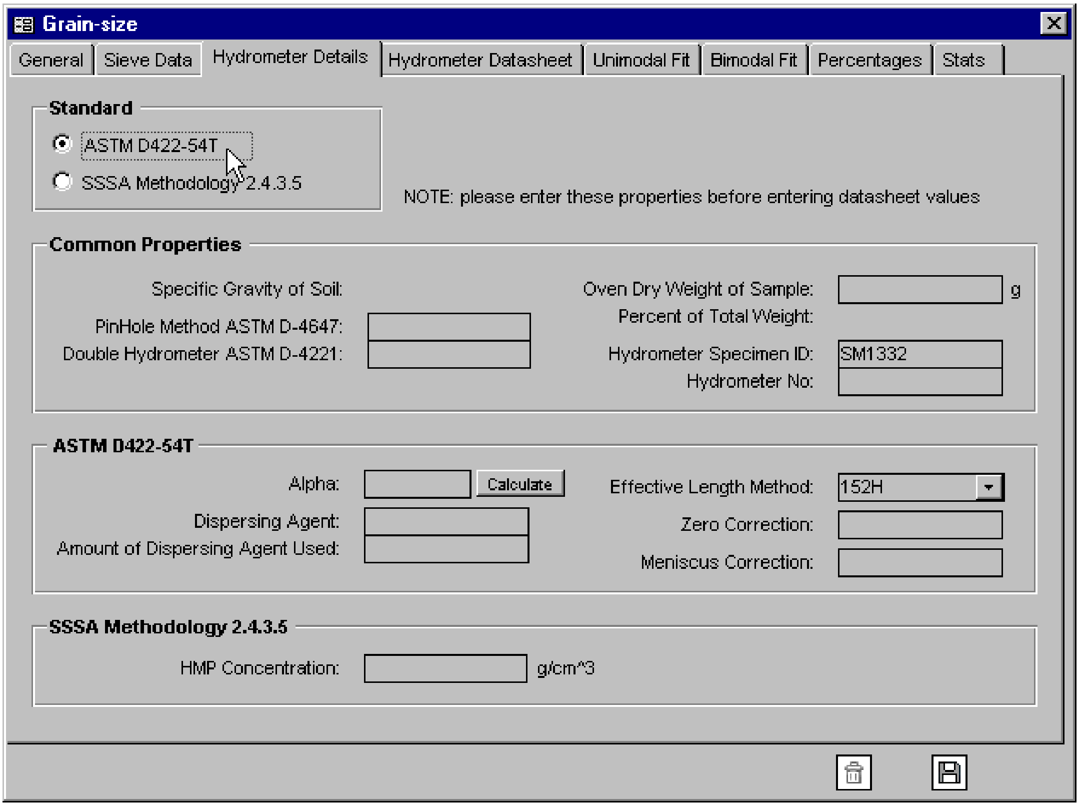
Templates button opens the Sieve Templates window where various sieve templates are stored. The Templates function allows the user to pre-define a group of sieves, or select a group of sieves that have been entered previously. Entry of sieve information into the Templates window is done with the same procedure as entering sieve data into the Laboratory Sieve Data window.



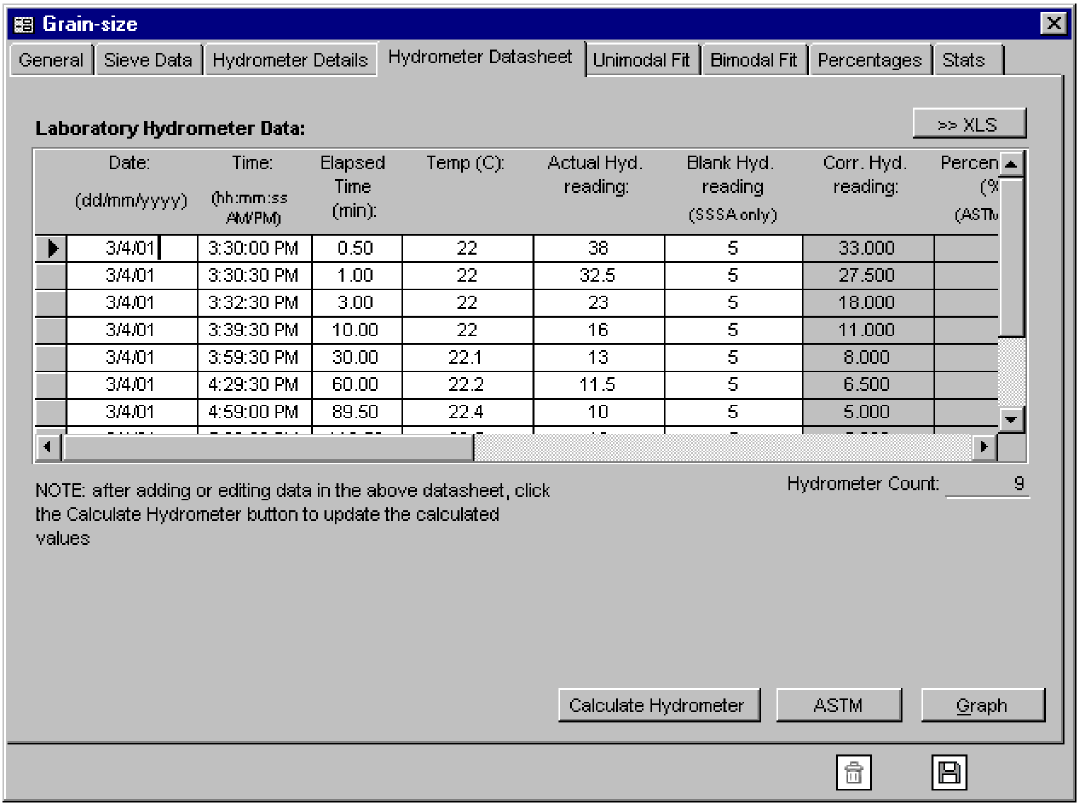
Graph button plots and displays a semi-log graph of Particle Size versus Percent Passing.

1.5.3 Hydrometer Details and Hydrometer Datasheet Tabs

The **Hydrometer Details** and **Hydrometer Datasheet** tabs contain all information related to the recording of a hydrometer analysis on a soil sample. An empty **Hydrometer Details** form is shown below. This form records the experiment parameters needed to perform the grain-size calculations for both the ASTM D422-54T standard and the SSSA 2.4.3.5 methodology. It is important that the standard you wish to use is selected in this form. You can change the default standard for new soil records in the **Preferences** form, found at **Tools > Preferences**.



The other half of the hydrometer information is the **Hydrometer Datasheet** tab. This form records the data collected during the hydrometer experiment. The fields that apply to only one calculation method (ASTM or SSSA standard) are labeled as such. An example **Hydrometer Datasheet** form is shown here.

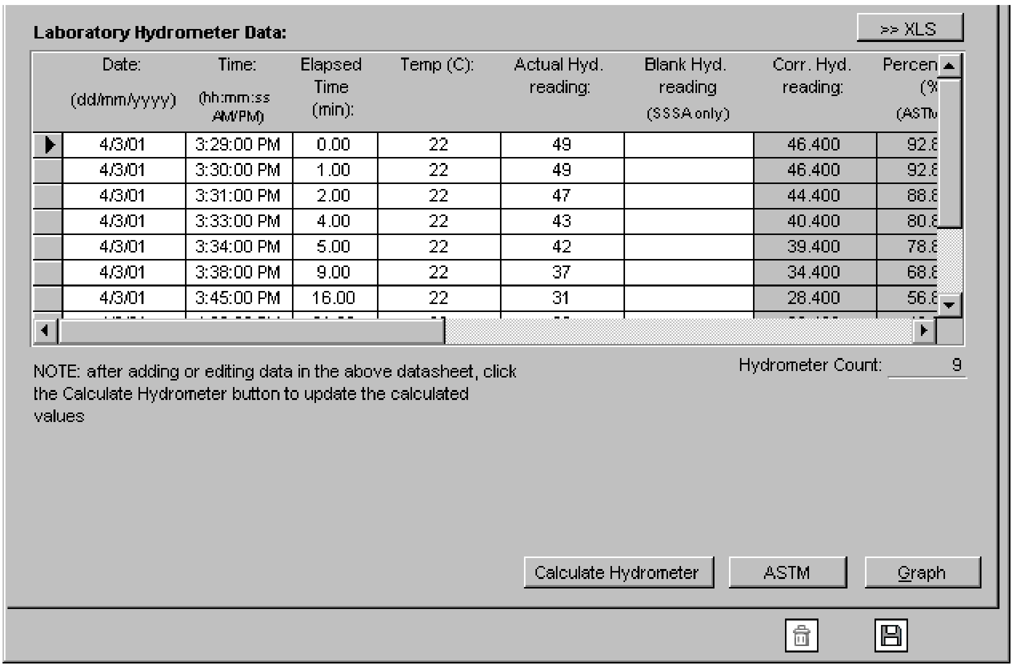


To illustrate the method of data entry into the **Hydrometer Data** form let us assume that the **Texture** and **Volume-Mass** tabs have both been filled out properly. Also, the information in the **General** tab must also be filled in. We will then start by filling in the appropriate information into the **Hydrometer Details** tab.

The first thing the user will notice is that the **Specific Gravity of Soil** has been forwarded from the **Volume-Mass** tab. The user should then fill in the **Oven Dry Weight of Sample**, **Effective Length Method**, **Zero Correction**, **Meniscus Correction**, and **Alpha**. If SSSA Methodology 2.4.3.5 is to be used, then the **HMP Concentration** should be filled in instead of the fields inside the ASTM D422-54T box. The **Percent of Total Weight** is automatically calculated using the values provided in the **Oven Dry Weight of Sample** field and the **Sieve Wt. Of Sample** field in the **Sieve Data** tab. The **Alpha** value is calculated from the **Specific Gravity of Soil** by pressing the **Calc>>** button. The rest of the required fields are input manually by clicking each field and entering the appropriate information. It should be noted that while only the aforementioned fields are required, the more information the use can input, the more accurate the results will be. As with the Sieve Data form, the optional Hydrometer Specimen ID field is provided to uniquely identify the soil specimen and is a subsidiary of the Sample ID field in the Soils form.
After the **Hydrometer Details** tab has been filled, we can then proceed to fill in the **Hydrometer Datasheet** tab. Let us assume that we have performed a hydrometer test that has yielded the following raw data.

Date (dd/mm/yyyy)	Time (hh:mm:ss)	Temp (C)	Actual Hydrometer Reading
03/04/2001	15:29:00	22	49
04/03/2001	15:30:00	22	49
04/03/2001	15:31:00	22	47
04/03/2001	15:33:00	22	43
04/03/2001	15:34:00	22	42
04/03/2001	15:38:00	22	37
04/03/2001	15:45:00	22	31
04/03/2001	16:00:00	22	26
04/03/2001	16:30:00	22	24
04/03/2001	16:35:00	22	21
04/03/2001	21:00:00	23	18
05/03/2001	8:00:00	23	16
05/03/2001	15:00:00	24	14
06/03/2001	15:00:00	24	10

The user can input the data by simply clicking the appropriate field and typing the data. The data given above represents the required data that is input into the first white fields which represent the minimum input. The gray and remaining white fields are automatically calculated from the information in their previously entered counterparts. It should be noted that the user can input data directly into the gray fields should the data be available. Once the data has been entered the user can press the **Calculate Hydrometer** button to fill in the empty gray fields in the form.



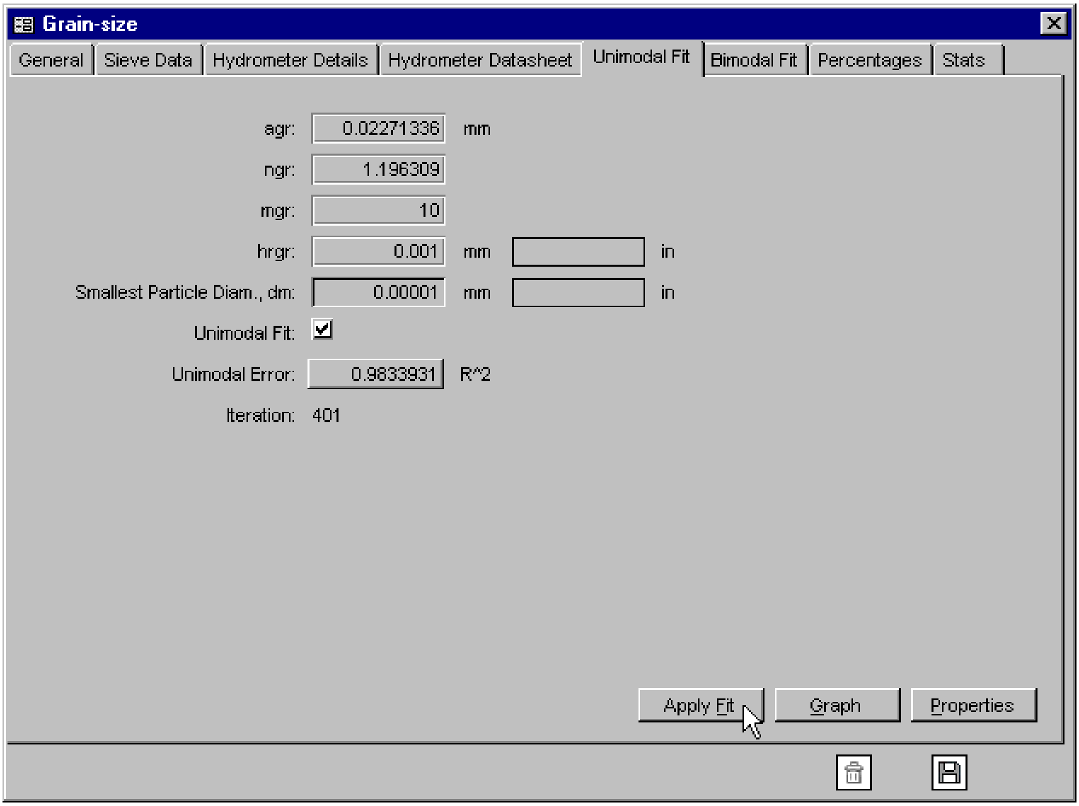
Other buttons on the **Hydrometer Datasheet form** perform the following functions:

- **ASTM** button opens a form that displays all ASTM defined sieve sizes for reference purposes.
- **>>XLS** button exports the data table as a Microsoft Excel spreadsheet.
- **Graph** button plots and displays a semi-log graph of Particle Size versus Percent Passing.

When either the Sieve Data or Hydrometer Data has been input properly the user can then proceed to classify the soil by the USDA method. Entry of Atterberg Limit data is required prior to classification by the USCS method.

1.5.4 Soil Classification

After sieve and/or hydrometer data have been entered the grain-size distribution must be fit with an equation. Fitting sieve and/or hydrometer data with an equation is required because % clay, % silt, % sand, and % coarse values are interpolated off the equation fit through sieve and/or hydrometer data. The % clay, % silt, and % sand values are then used as a basis for the USDA and USCS classification algorithms. Fitting of sieve and/or hydrometer data is accomplished by going to the **Unimodal Fit** and/or **Bimodal Fit** tabs where the **Apply Fit** button is pressed (only the **Unimodal** window is shown since the **Unimodal** and **Bimodal** windows are very similar).



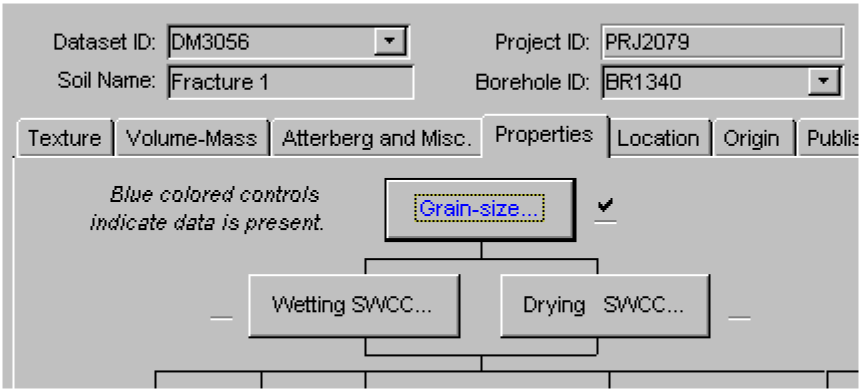
The equation will provide a continuous method of interpolation. The fit equation algorithm also initiates the following calculations:

- calculation of % clay, % silt, % sand, and %coarse for the USDA and USCS (ASTM) methods
- calculation of D_{10}, D_{20}, D_{30}, D_{50}, and D_{60}
- classification of the current soil by USDA and USCS (ASTM) methods

The calculations shown above are performed using the equation (Unimodal/Bimodal) that best represents the soil. The success of the equation in fitting the laboratory data is determined by the Error R^2 variable. With the R^2 methodof measurement, a perfect fit is represented as a value of 1.00. It is important to note that the results of the equations will **OVERWRITE** the USDA and USCS soil textures in the **Texture Tab** of the **Soils form**.

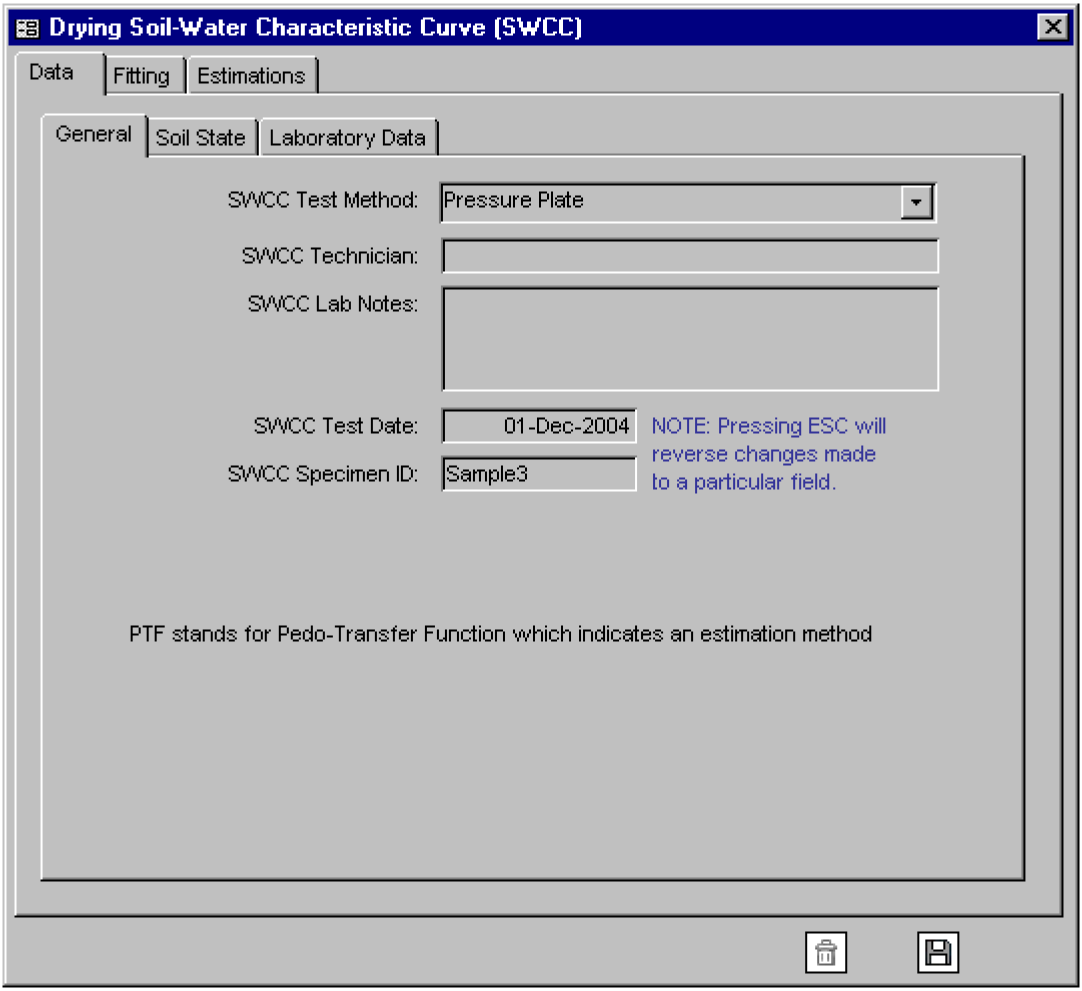
1.6 SWCC INFORMATION

Once **Grain-size** information and soil classification has been completed the user must then proceed to the input of **SWCC** (Soil Water Characteristic Curve) data. Referring to the **Properties** tab of the **Soils** form, one will notice that in order to be able to estimate additional test information such as **Permeability** or **Diffusion**, either the **Drying** or **Wetting SWCC** information must be available. This is because these tests are related to the unsaturated properties of a soil, and therefore require a description of the amount of water present in a soil for a particular soil suction.



1.6.1 Drying SWCC Information

Central to the behavior of an unsaturated soil is the relationship between the amount of water, and soil suction as the soil desaturates or dries. Entering the **Drying SWCC** form is accomplished by pressing the **Drying SWCC** button on the **Properties** tab of the **Soils** form.



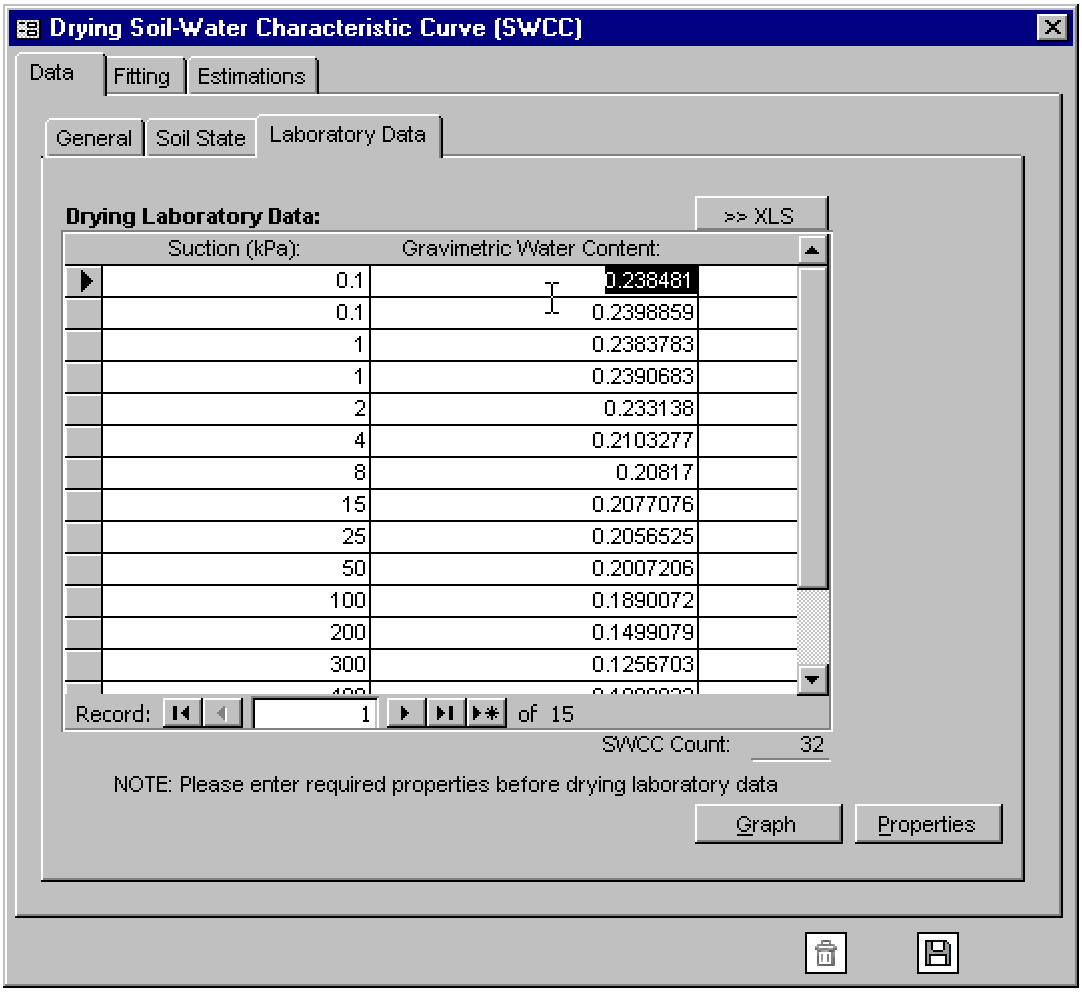
The main **SWCC Drying form** has three primary tabs: **Data**, **Fitting**, and **Estimations**.

1.6.1.1 Data Tab

The **General** tab is where the user will fill in general information such as test method and lab notes. Only the **Test Method** is essential.

The **Soil State** tab displays information on the assumed state of the soil at the beginning of the laboratory procedure. This information cannot be altered and is there for reference purposes only.

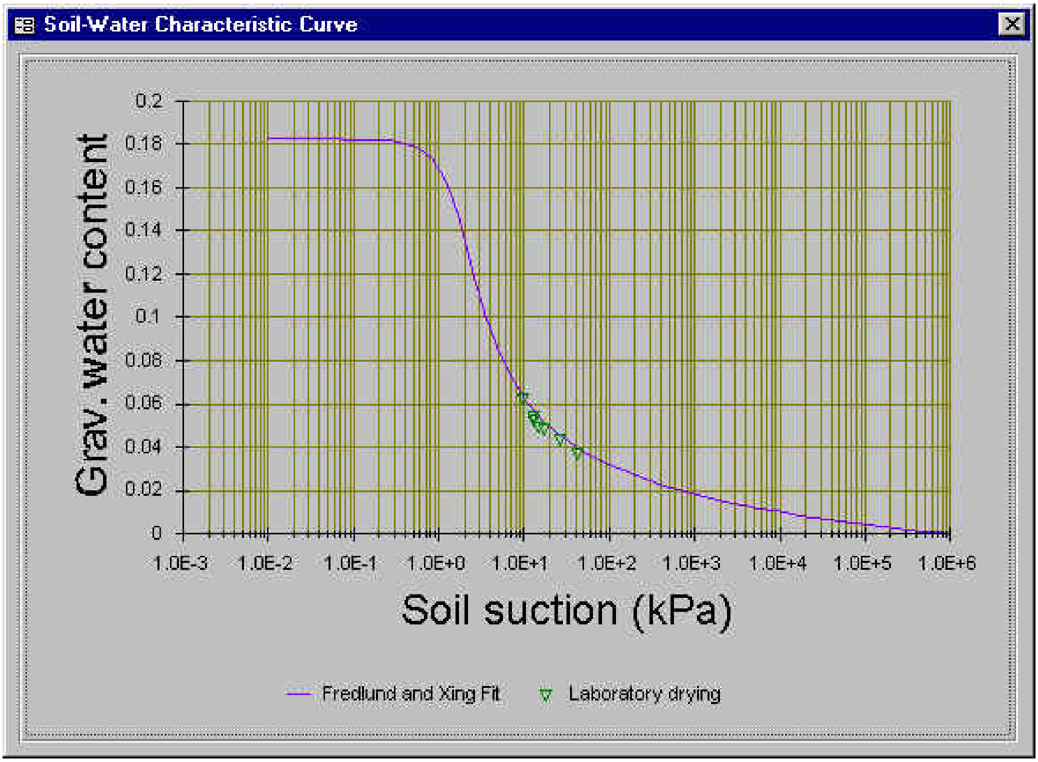
The **Laboratory Data** tab is where the user enters data from a SWCC test to be fit with one of the equations contained in the other tabs in the **SWCC Drying form**. The user should note that Suction data in kPa and Gravimetric Water Content are the required types of raw data needed for Wetting SWCC calculation. To enter data into the form, simply click the field and enter the data.



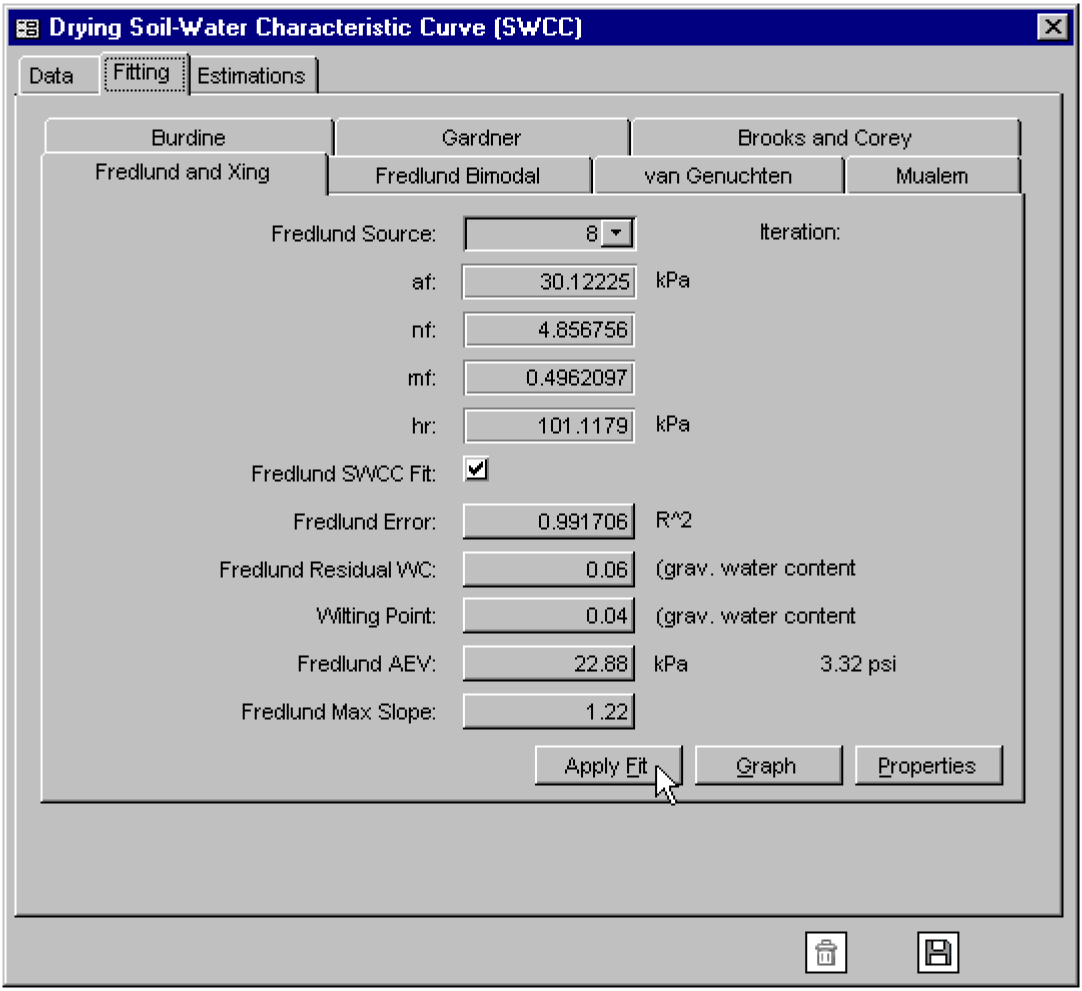
- **Properties** button displays the specifics of the equation used and its origin
- **>>XLS** button exports the data table as a Microsoft Excel spread sheet.
- **Graph** button plots and displays a semi-log graph of Gravimetric Water Content versus Suction

1.6.1.2 Fitting and Estimations Tabs

The seven fitting tabs in the Drying SWCC window allow the user to compare the laboratory data with three seven equations. To accomplish this the user can click the **Apply Fit** button in any of the three comparison tabs (Fredlund and Xing shown below) to fit a curve to the laboratory data previously entered. An example of such a plot is shown below.



The **Graph** and **Properties** buttons function in the same manner as those on the **Laboratory Data** tab.



The estimations tab provides the user access to the estimations methods implemented in SoilVision. See Estimation of Unsaturated Soil Properties in Chapter 2.0 for more information.

1.7 PERMEABILITY INFORMATION

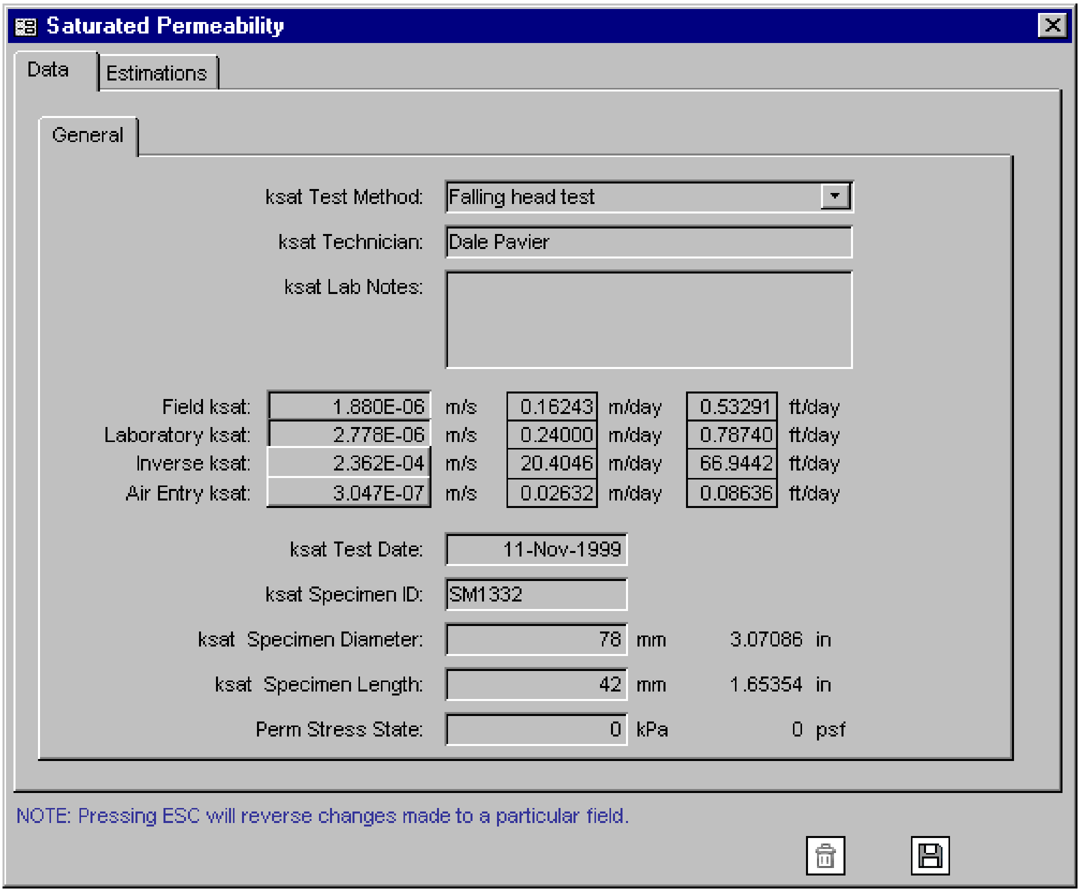
Permeability information is contained within its own "branch" on the **Properties** tab of the **Soils** form.

1.7.1 Saturated Permeability

SoilVision has implemented the management of saturated permeability data as well as a number of methods of estimating the saturated permeability of a soil. Entering the **Saturated Permeability** form is accomplished by pressing the **Saturated Permeability** button on the **Properties** tab of the **Soils** form.

1.7.1.1 Data Tab

The **Data** tab contains general information as determined in the laboratory. A field or laboratory determined saturated permeability may be recorded. To enter data, click the appropriate field and type in the value.

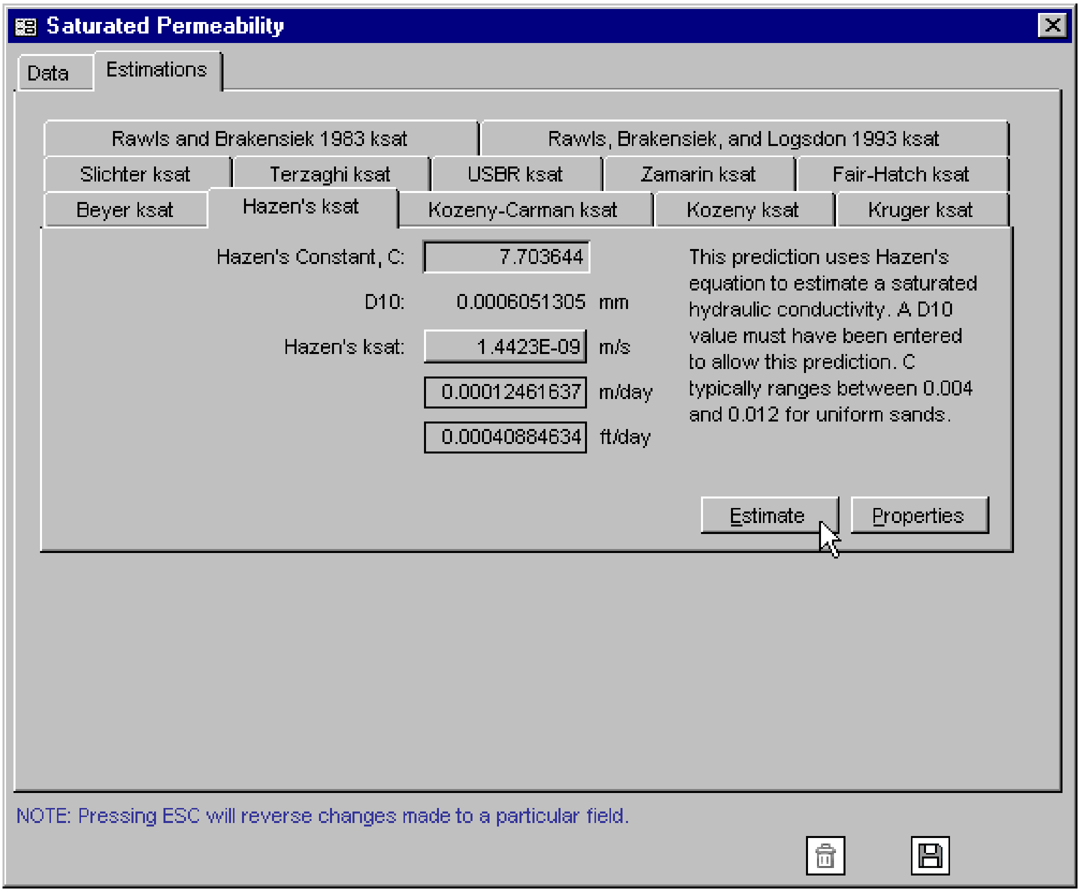


Minimum Recommended Input

ksat Test Method
ksat Technician
Laboratory ksat
ksat Test Date
ksat Specimen ID

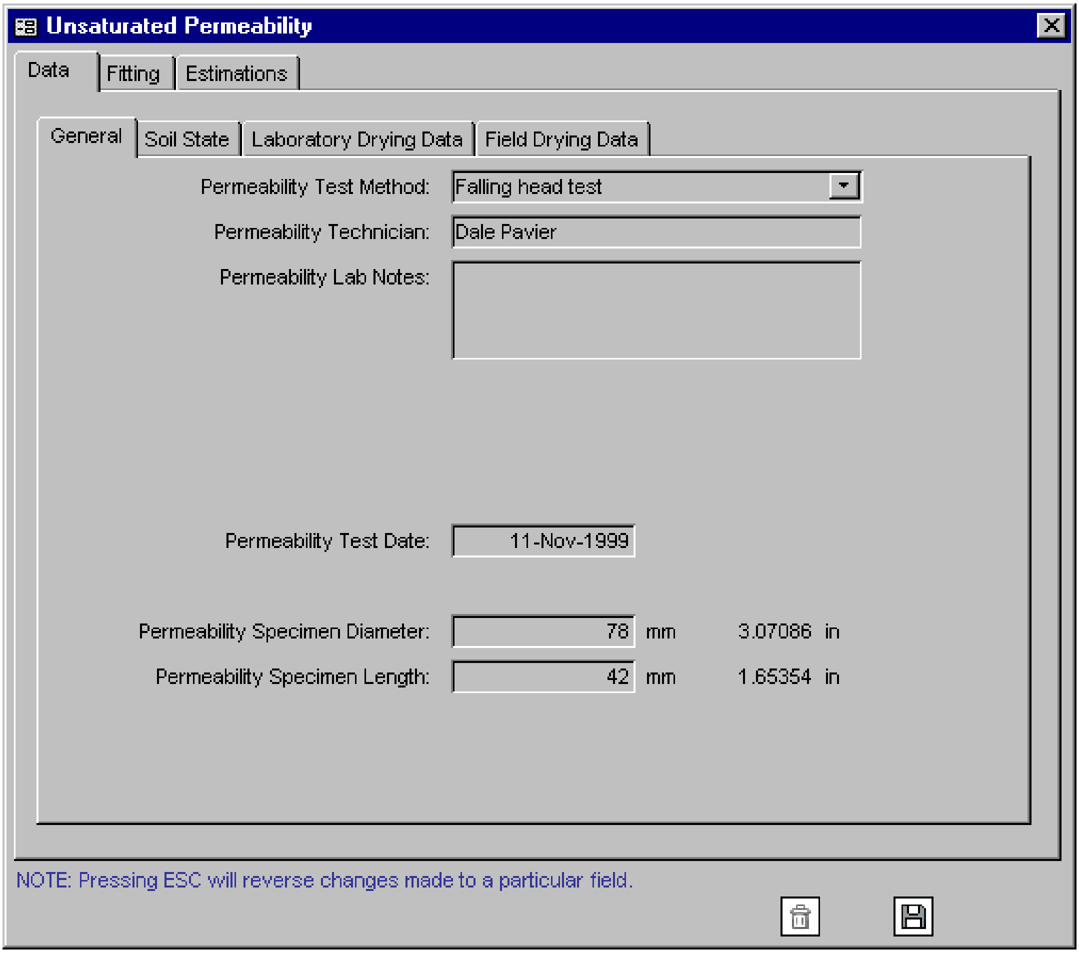
1.7.1.2 Estimations Tab

The **Estimations** tab contains all the methods of estimating saturated permeability currently implemented in the SoilVision software. A description of these methods may be found in the SoilVision Theory Manual.



1.7.2 Unsaturated Permeability

SoilVision provides the ability to both store unsaturated soil data as well as estimate the unsaturated soil permeability as a function of soil suction. Entering the **Unsaturated Permeability** form is accomplished by pressing the **Unsaturated Permeability** button on the **Properties** tab of the **Soils** form.



1.7.2.1 Data Tab

The **Data** tab contains information related to the laboratory testing of unsaturated permeability. The **Soil State** tab contains the suggested theoretical initial state of the unsaturated permeability test. The L**aboratory Data** tab allows entry of the data regarding the unsaturated permeability test as a function of permeability versus soil suction. Similarly the **Field Data** tab allows entry of the data regarding field measurement of unsaturated permeability as a function of soil suction. In each of these tabs, data is entered is the same way as is described in the **Drying SWCC** section.

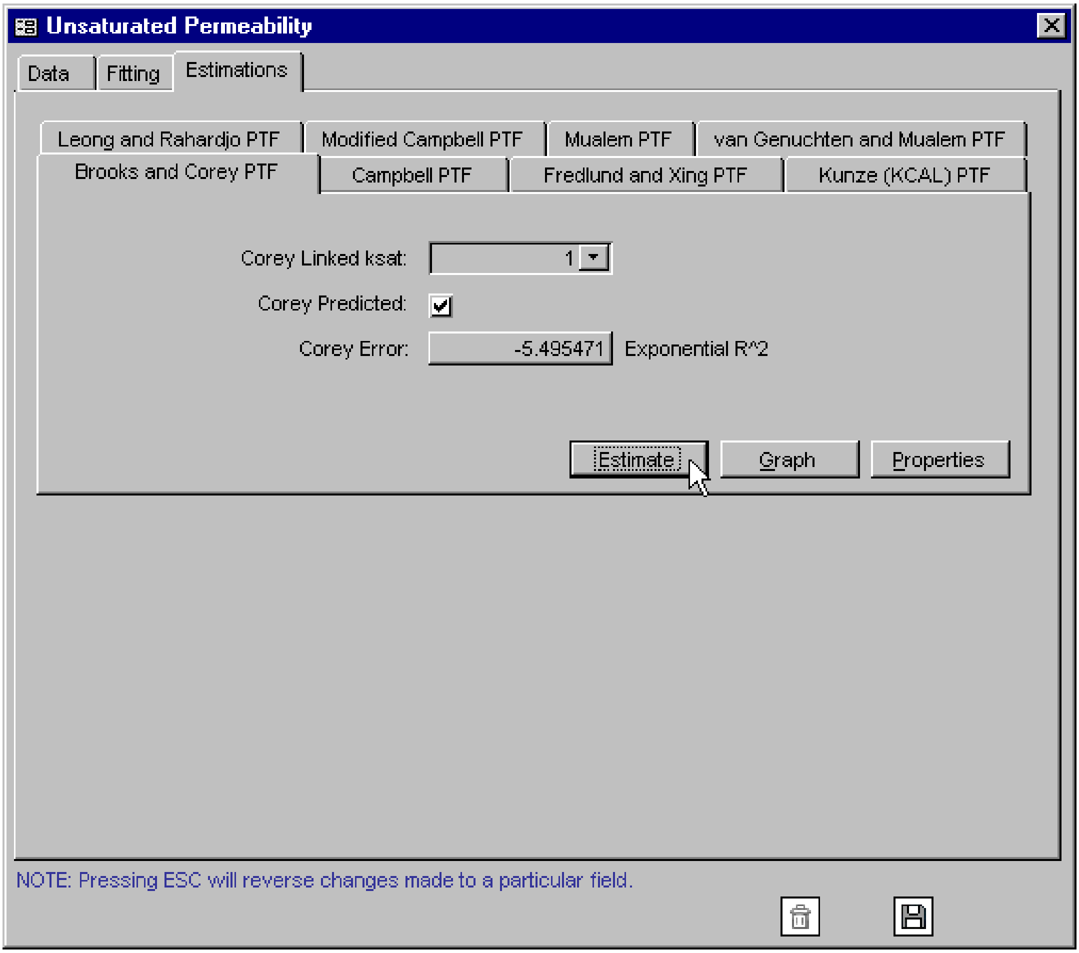
Minimum Recommended Input

Permeability Test Method
Permeability Technician
Permeability Test Date

1.7.2.2 Fitting Tab

The Fitting tab provides access to the Gardner method of fitting unsaturated permeability laboratory data. Fitting the Gardner equation to data is accomplished through a nonlinear least-squares fitting algorithm. While possible, fitting the Gardner equation to permeability data often leads to less than optimum results. The reason for this is that the large possible range of permeability values makes fitting difficult. It is suggested that the user pay close attention to the quality of the fit as presented by the R^2 value.

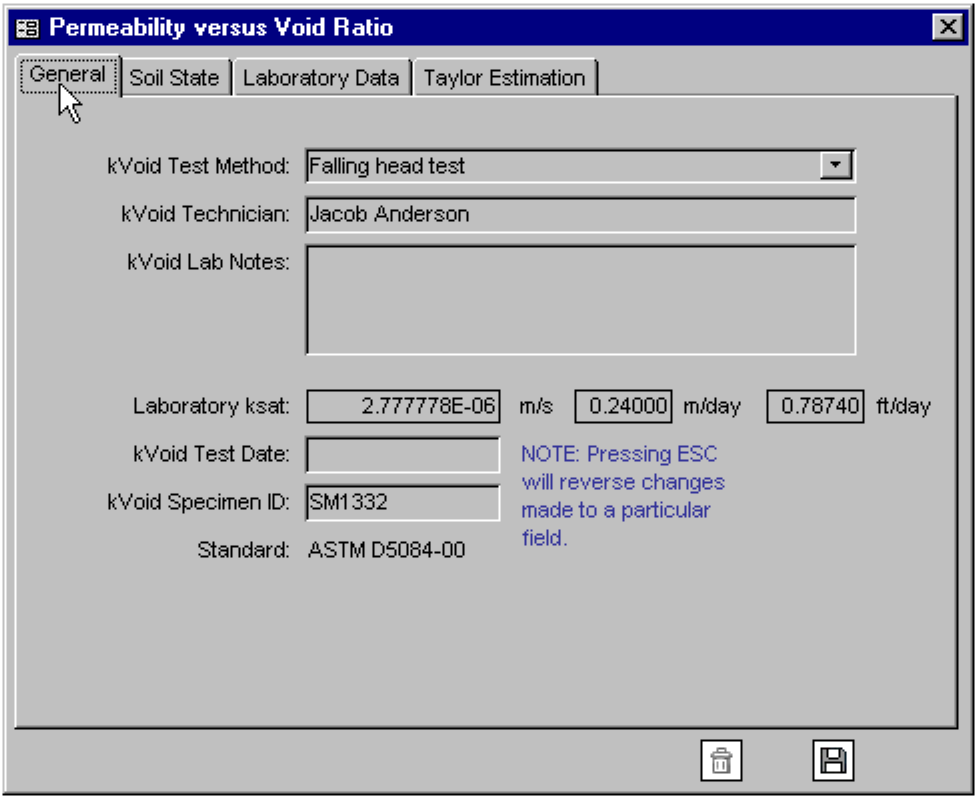
1.7.2.3 Estimations Methods Tab



Laboratory measurement of the variation of permeability with soil suction is very time consuming and expensive. It has become generally accepted practice to estimate the unsaturated permeability curve based on the soil-water characteristic curve. SoilVision provides a host of methods for performing this estimation. Estimation of the unsaturated permeability function using two methods may be seen in the following chapter regarding estimating unsaturated soil properties.

1.7.3 Permeability versus Void Ratio

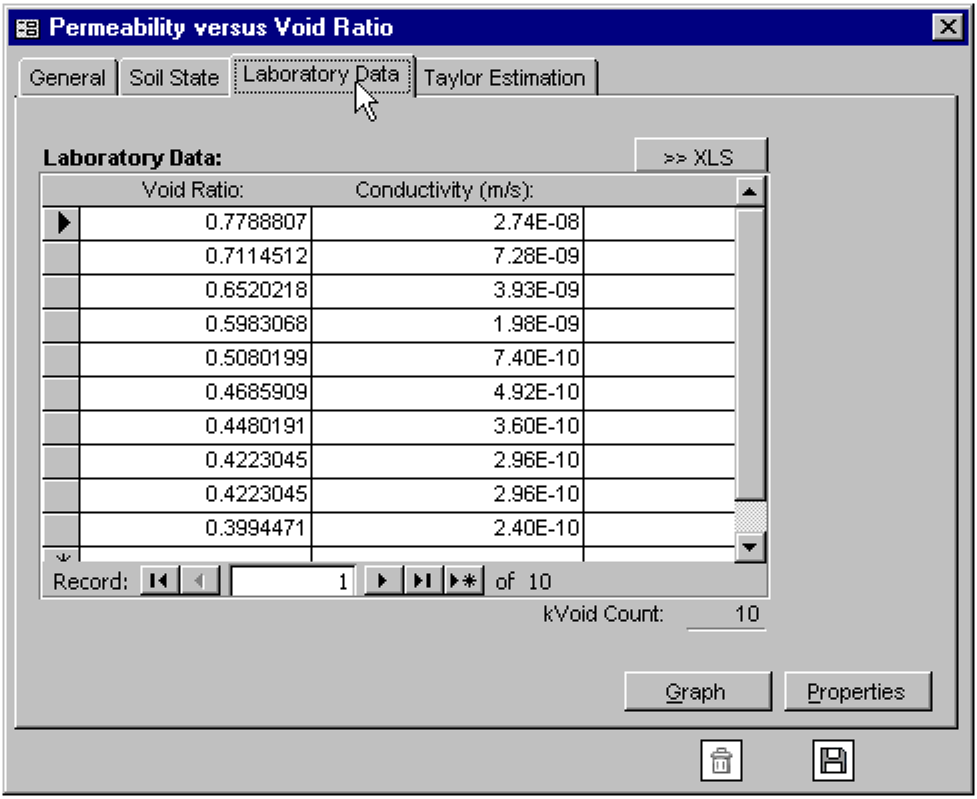
SoilVision provides the ability to both manage laboratory data as well as mathematically represent the relationship between **Permeability** and **Void Ratio**. The permeability vs. void ratio form may be displayed by pressing the **Permeability vs. Void Ratio** button in the **Properties** tab of the **Soils** form.



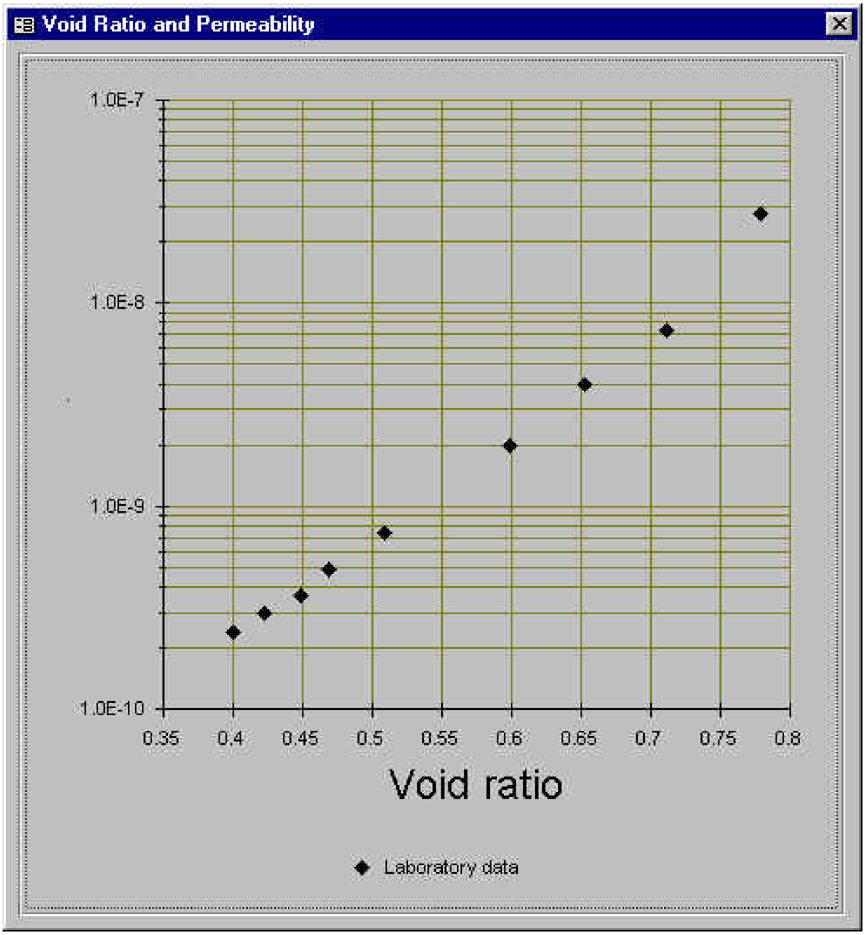
Minimum Recommended Input

kVoid Test Method
kVoid Technician
kVoid Test Date
kVoid Specimen ID

The laboratory method must first be entered. Once a method has been entered the user may proceed with the entry of laboratory data shown below.



Once the laboratory data has been entered, it may be graphed by clicking the **Graph** button.


Void Ratio and Permeability
1.0E-7
1.0E-8
1.0E-9
1.0E-10
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
Void ratio
Laboratory data

2 ESTIMATING UNSATURATED SOIL PROPERTIES

In the estimation of unsaturated soil properties, the two most important properties considered are the soil water characteristic curve and the saturated and unsaturated permeability. SoilVision allows for the theoretical estimation of both of these properties. The following sections outline the methods necessary for performing a theoretical estimation of unsaturated water retention and permeability.

For the estimation of unsaturated soil properties it is most typical that the user would be attached to the SVSoils_Demo database to follow the examples outlined below.

2.1 THEORETICAL ESTIMATION OF SWCC

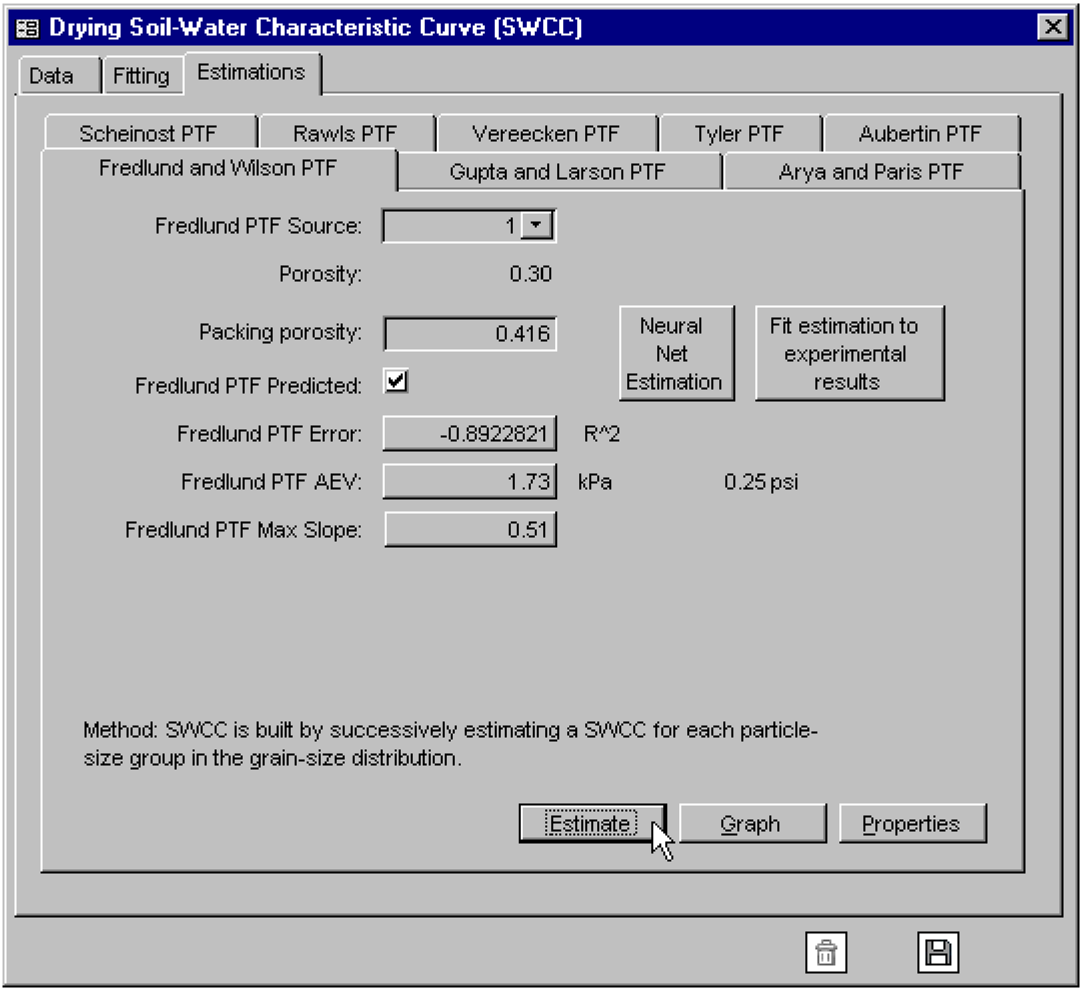
Seepage modeling requires the use of the Soil-Water Characteristic Curve (SWCC) to present the water content of a soil under various soil suctions. The SWCC is typically measured experimentally using a pressure-plate apparatus. This procedure is costly and alternate estimation methods are often desirable. SoilVision implements seven estimation techniques (also called pedo-transfer functions) for predicting the SWCC. The following section outlines the procedure for estimation of the SWCC by theoretical methods.

The first step in this process is to create a new soil record and enter the sieve analysis. Most methods of estimating the SWCC require grain-size information either in the form of a sieve analysis or represented as % clay, %silt, and % sand variables. It is best to enter as much information as possible. See the **Entering New Data** section of the tutorial for details on how to enter this information into the database.

The data requirements are different for each estimation method. The data required for each estimation technique is specified in the Properties dialog box (see “pointer” in following screen shot).

Generally, what is required for most SWCC estimation methods is a description of the grain-size distribution and three insitu volume-mass properties such as porosity, dry density, and specific gravity. See the **Volume-Mass** tab of the **Soils** form for entering three volume-mass properties.

Once project, borehole, and grain-size information have been input, attention may proceed to the **SWCC Drying** form to perform the theoretical estimations. The **SWCC Drying** form may be found on the **Properties** tab of the **Soils** form.



The estimation algorithms may be initiated under the **Estimations** tab of the **SWCC Drying** form. Initiating each estimation algorithm causes the following steps to be performed. The estimated curve is calculated in temporary memory. The R^2 value is calculated if laboratory data is present

If no laboratory data is present performing the estimations algorithm is merely a check that all data required to perform the estimation is present. SoilVision will display messages indicating the problem if required data is not present.

Once the estimation has been performed, it is desirable to view the results of the estimation. The results of the estimation may be viewed under the **Graph** or **Report** menu options. The **SWCC Graph Wizard** handles the graphing of all SWCC fits, estimations, and laboratory data.

A comparison of the various estimation techniques may be found in the PhD thesis of M.D. Fredlund entitled, “The role of unsaturated soil property function in the practice of unsaturated soil mechanics” published at the

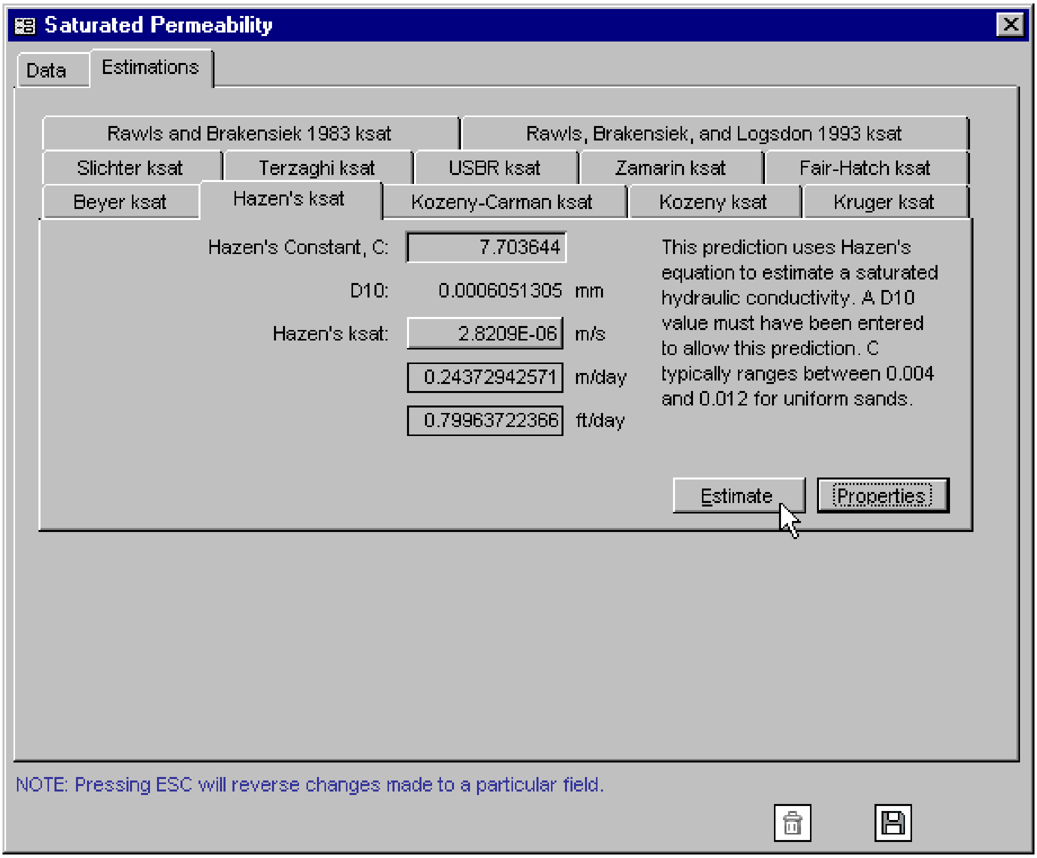
University of Saskatchewan. A description of the theory behind each estimation method may be found in the Theory Manual.

2.2 THEORETICAL ESTIMATION OF PERMEABILITY

Seepage modeling in soils requires a description of the hydraulic properties of a soil. SoilVision provides the user with a number of methods for estimating both the saturated hydraulic conductivity and the hydraulic conductivity as a function of soil suction. It is often useful to estimate the properties of a soil due to the high cost of laboratory procedures. The following sections outline methods of estimating saturated hydraulic conductivity of a soil. The methods are implemented based on their frequent use in the practice of geotechnical engineering and soil science.

2.2.1 Estimation of Saturated Conductivity

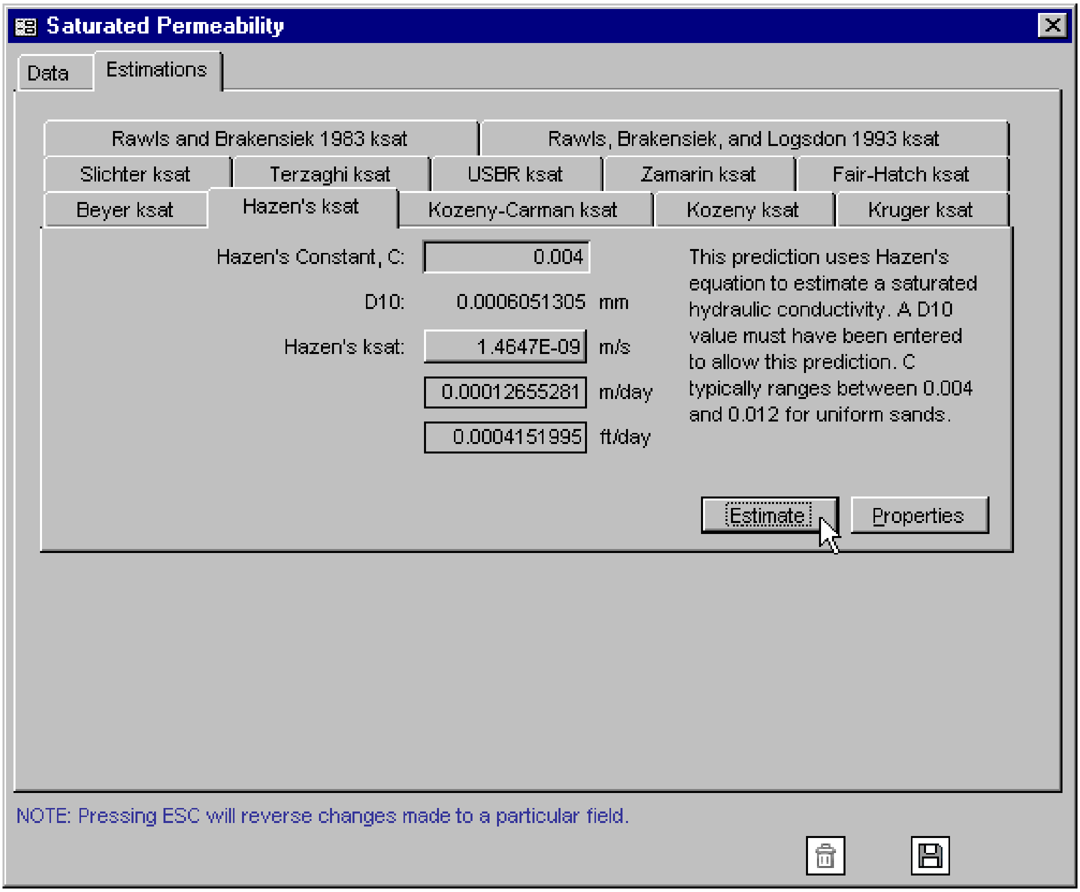
SoilVision implements a comprehensive range of theoretical methods for estimation of saturated permeability. Each method is summarized in its respective tab as shown below.



It is important to note the requirements for the estimation methods. The requirements are outlined in the tab dedicated to each estimation method in the **Permeability** form. The majority of methods require a description of the grain size distribution or %clay, % silt and, % sand as a minimum requirement. The Kozeny-Carman method also requires the soil-water characteristic curve to be fit with the Fredlund and Xing equation.

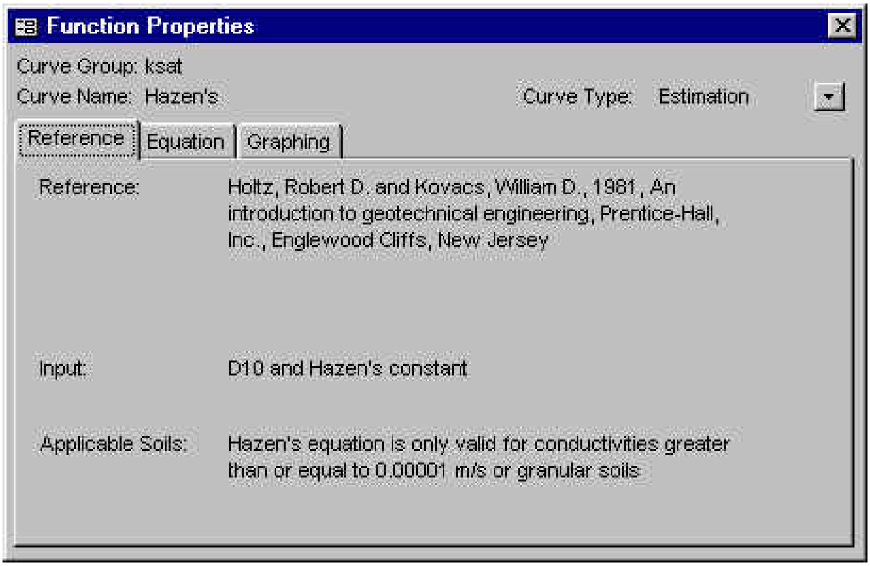
Once the prerequisites are fulfilled, the user may proceed with performing the estimations. The various estimation techniques may be initiated under the **Estimation** menu option or by pressing the **Estimate** button. The estimations may be performed individually or as a group. Once the estimation has been successfully performed, a saturated permeability will be placed in the appropriate field.

Performing an estimation may be accomplished be first clicking on the tab of the desired estimation method. For example, if the user desires to estimate saturated permeability by Hazen's method then the user must first click on the **Hazen's ksat** tab. Once the **Hazen's ksat** tab is displayed, the user is presented with fields related to the estimation of ksat by Hazen's method. A constant, C, is required for the estimation of ksat. The C constant ranges between 0.004 and 0.012 for uniform soils. For now let's say the user enters 0.004. Performing the estimation is accomplished by pressing the **Estimate** button. If all required information is present, then the estimated ksat value will be displayed in the Hazen's ksat field.

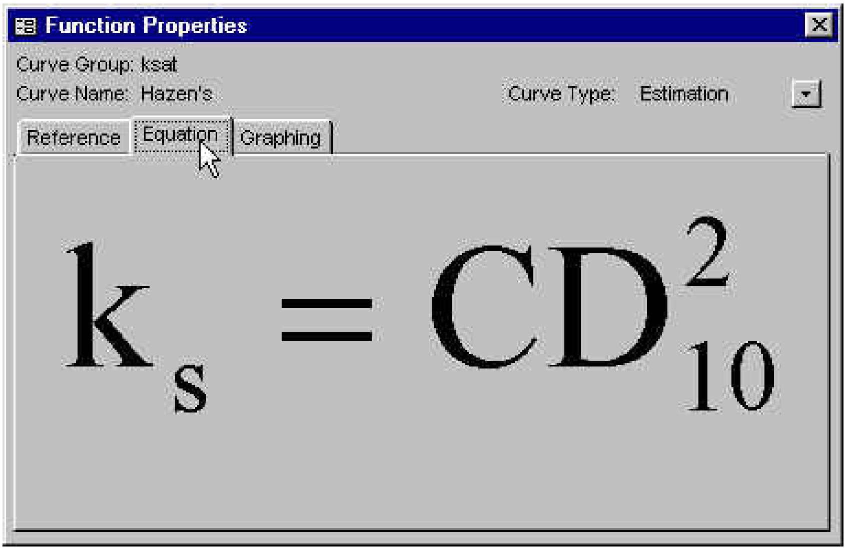


If the estimation is not performed, it is often because required information is not present. For the most part SoilVision will indicate to the user what information is missing in the error message.

The user may also find the information is needed for the estimation by pressing the **Properties** button in the **Estimations** tab of the **Saturated Permeability** form.



The Properties form lists the input required for the current estimation as well as the reference of the paper or text used to implement the method. Additional details of the estimation method may be found by looking up the original text or journal paper. The equation used in the estimation is also presented in the **Equation** tab.



Common questions regarding these estimation methods are as follows:

- **"How well do they work?"**
  No endorsement of estimation methods is implied by the implementation in SoilVision. It is recommended that the user look up the text or journal paper which originally presents these methods to determine the confidence the original author places in them.

  SoilVision does however, allow the user to get a feel for the possible variation of a certain estimation method. The method involves comparing the theoretical results of an estimation to the 2500 laboratory measured ksat values contained in the SoilVision database. The method is presented in section 2.5.2.

- **"For what soils are they applicable?"**
  A short description of applicable soils taken from the original paper is presented in the Properties form. It is recommended that the user look up the original text or journal paper for more details.

2.2.2 Unsaturated Soil

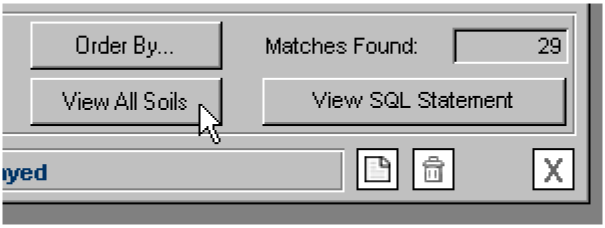
Water flows generally where there is a continuous representation of the water phase within soil structure. As a soil de-saturates, there is a decrease in the ability of the soil to conduct water under a pressure gradient. This decrease in hydraulic conductivity is extremely difficult to measure in the laboratory. It has become generally accepted practice to estimate the unsaturated hydraulic conductivity by theoretical methods.

SoilVision implements a variety of methods for estimating unsaturated hydraulic conductivity. Estimating hydraulic conductivity using the **Fredlund and Xing** and **Leong and Rahardjo** methods is outlined in this tutorial.

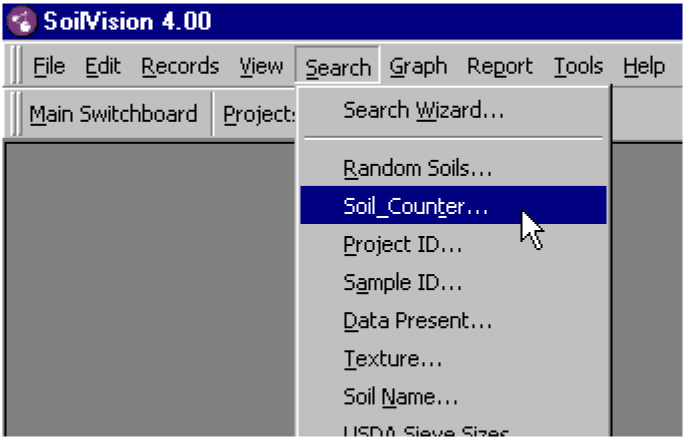
Soil 948597316 in the demo database will be used in the following tutorial and should be opened by the user. Once the demo database is opened, the user may proceed to soil 948597316 with the following steps.

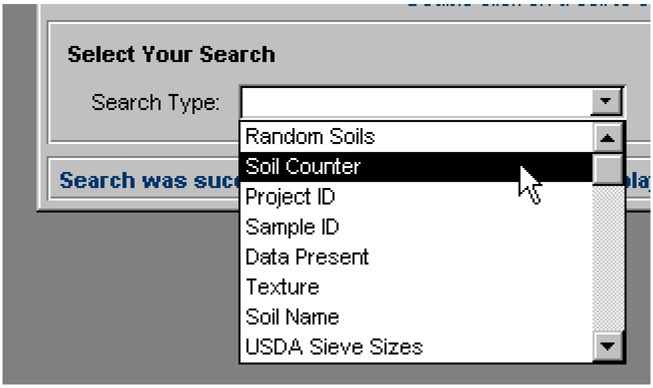
1. Navigate to the Soil Summary and Searching form.

2. Press the View All Soils button at the bottom of the form to clear any search that has previously been performed.

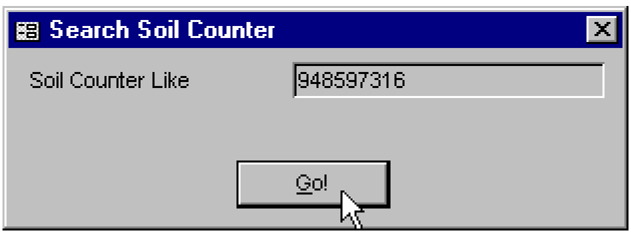


3. Select Soil_Counter… from the Search menu on the main tool bar, or select Soil Counter from the Search Type combo box.





4. With the Search Soil Counter form opened, type in 948597316 into the field and click Go!. Soil 948597316 should now be the only record showing in the window.

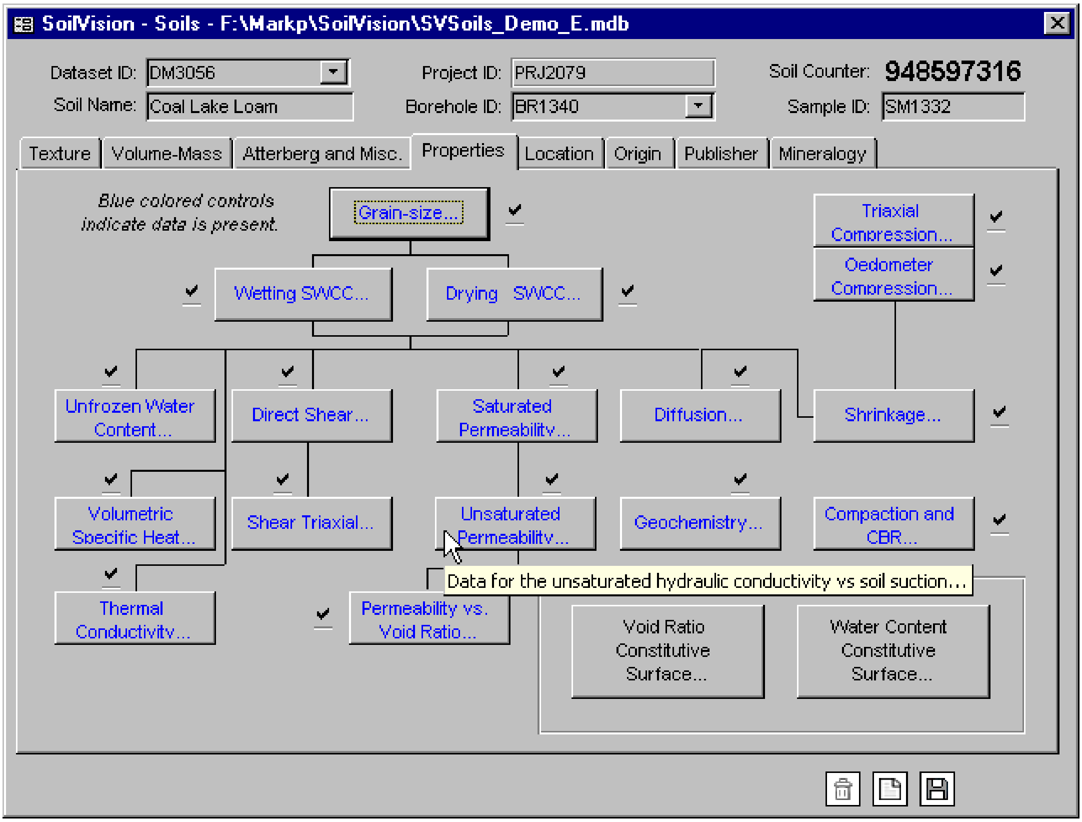


5. Double-click on the soil record, and the soil should open into the Soils form.

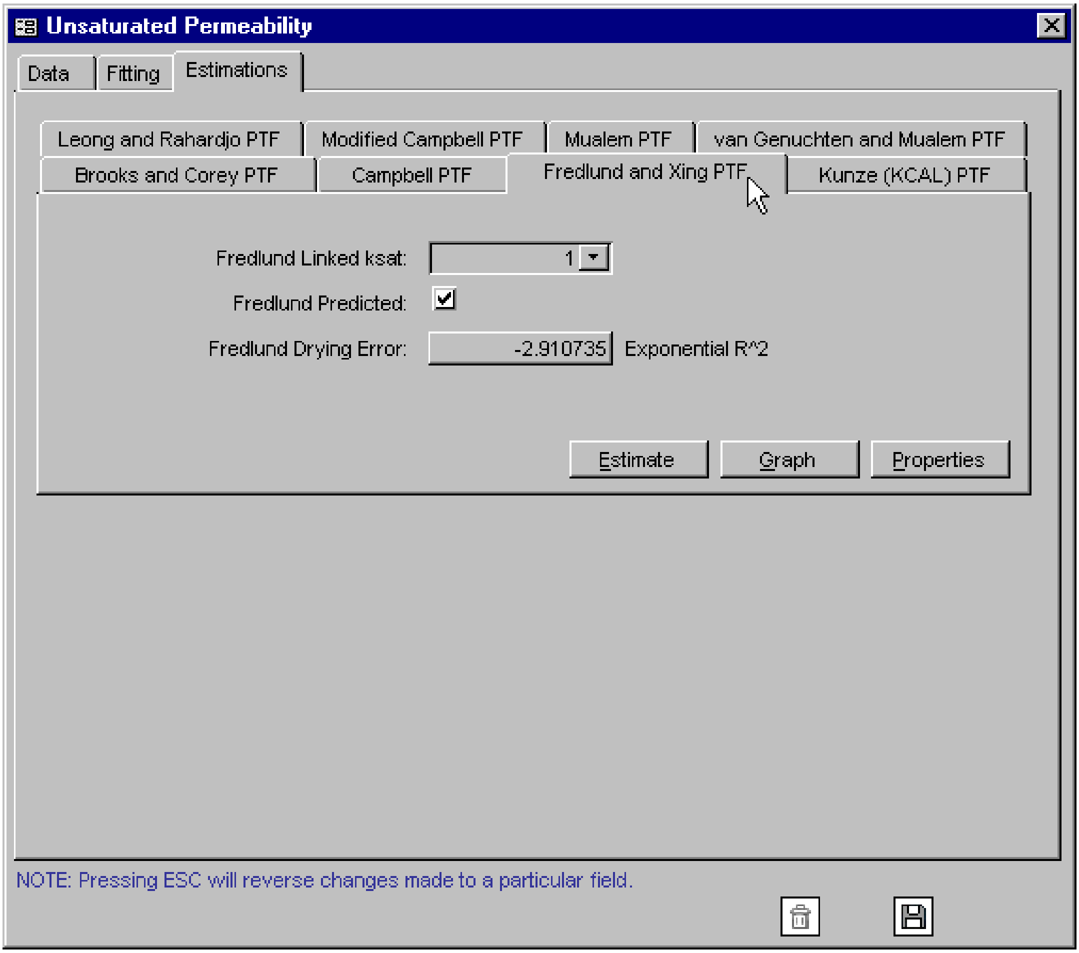
The soil-water characteristic curve and the unsaturated hydraulic conductivity curve are theoretically related. The soil-water characteristic curve is therefore used as a basis for the theoretical prediction of the soil-water characteristic curve. Estimation of the hydraulic conductivity therefore requires that a representation of the soil-water characteristic curve be present. More specifically, the **Fredlund and Xing** and **Leong and Rahardjo** estimations require that a fit of the soil-water characteristic curve by the **Fredlund and Xing** equation be

present. Soil 948597316 was selected for use in this tutorial because it includes the **Fredlund and Xing** fit of the soil-water characteristic curve.

The user may now proceed to the **Unsaturated Permeability** window by clicking the **Unsaturated Permeability** button under the **Properties** tab of the **Soils** form.

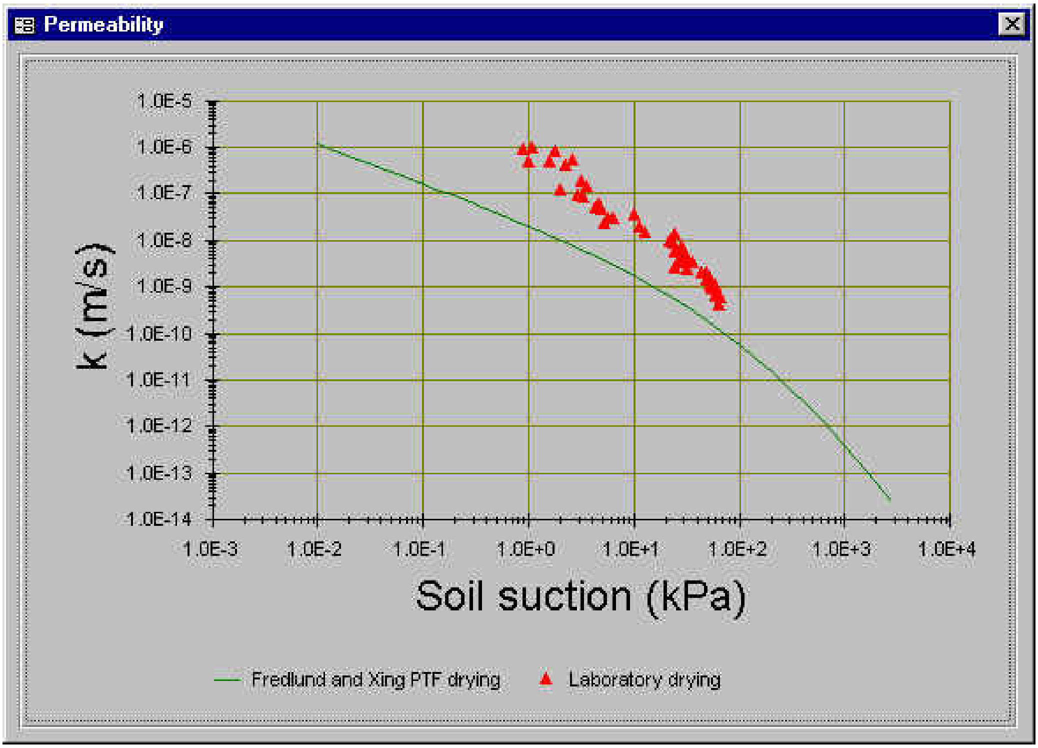


If an unsaturated permeability record does not exist, the use may create one by entering a laboratory test method. In the current example, a record already exists so the user may proceed to the **Estimations** tab that contains all the estimation methods currently contained in SoilVision.

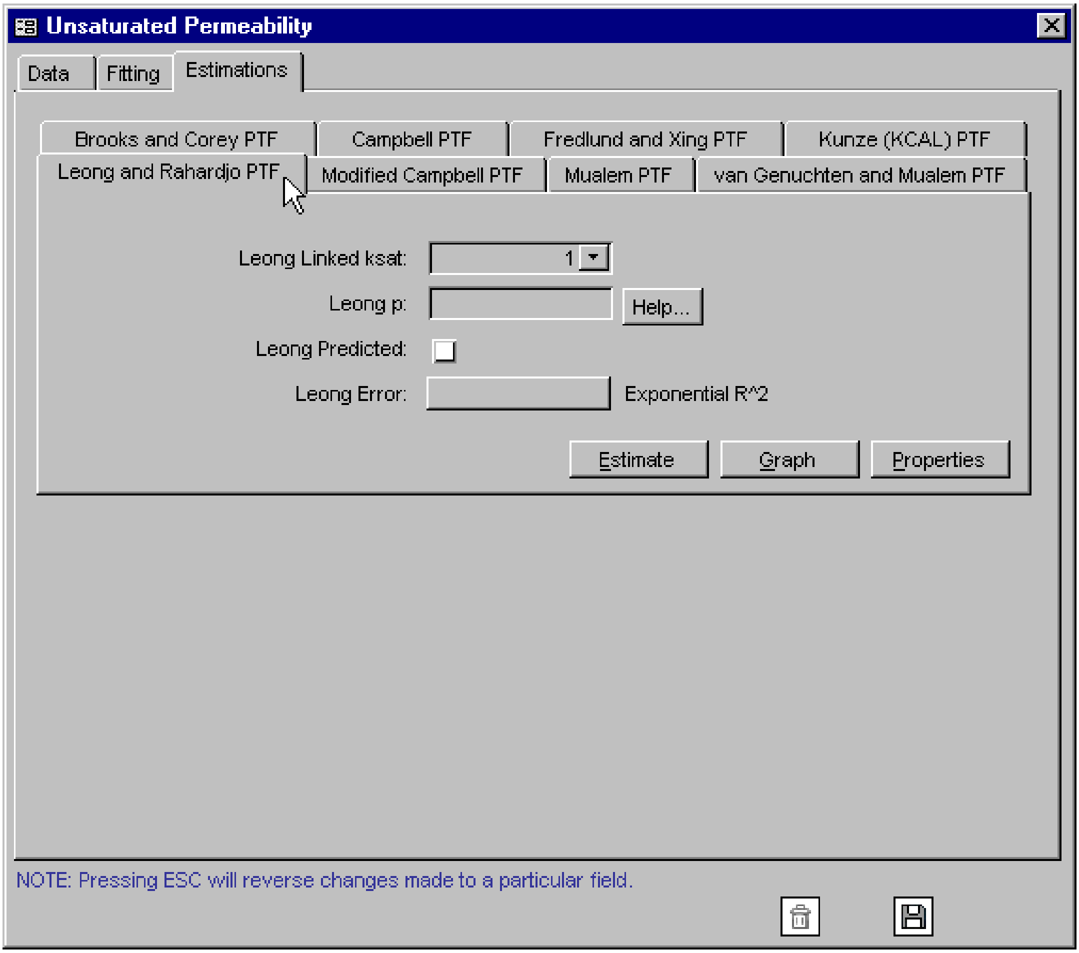


The first estimation we will perform will be with the **Fredlund and Xing** estimation method. Information related to this method is shown under the Properties button of the **Fredlund and Xing** tab shown in the previous screen shot. The **Fredlund Linked ksat** field must first be selected. The **Fredlund Linked ksat** indicates a starting point for the unsaturated portion of the hydraulic conductivity. Each estimation method may be linked to the laboratory ksat value or any of the theoretical ksat values estimated.

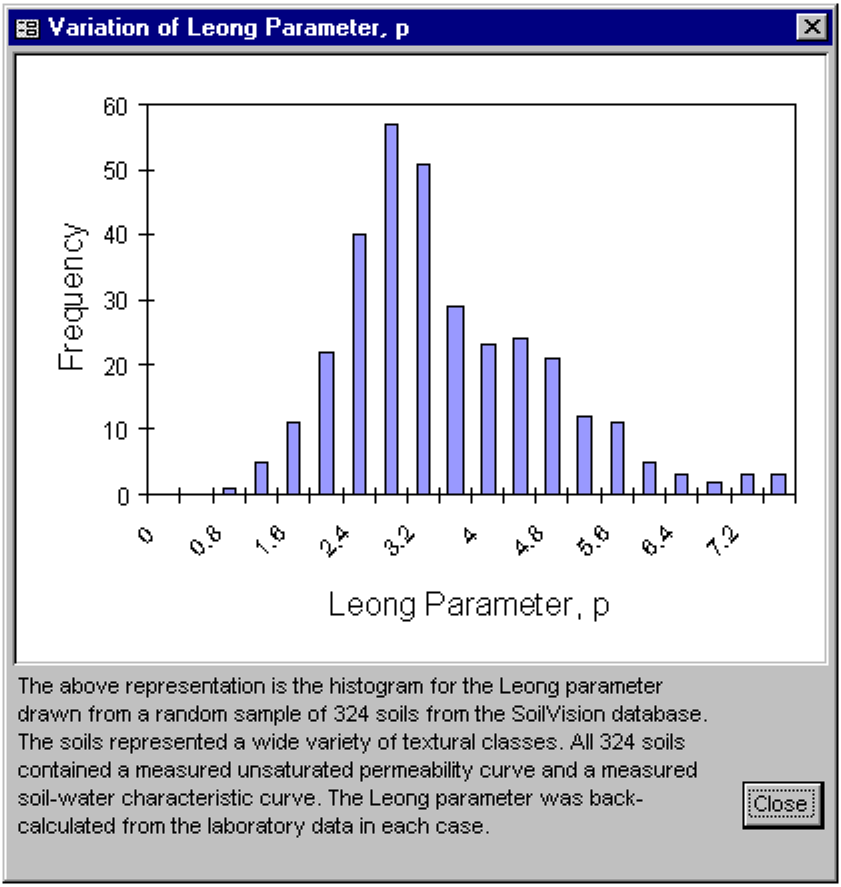
Since a **Fredlund and Xing** fit of the soil-water characteristic curve is already present, we may proceed with the estimation by pressing the **Estimate** button. The estimation is then performed, and if experimental lab hydraulic conductivity data is present, an R^2 value will be computed. The results of the estimation are presented in the form of a graph, which is viewed by pressing the **Graph** button. The generated graph is shown here.



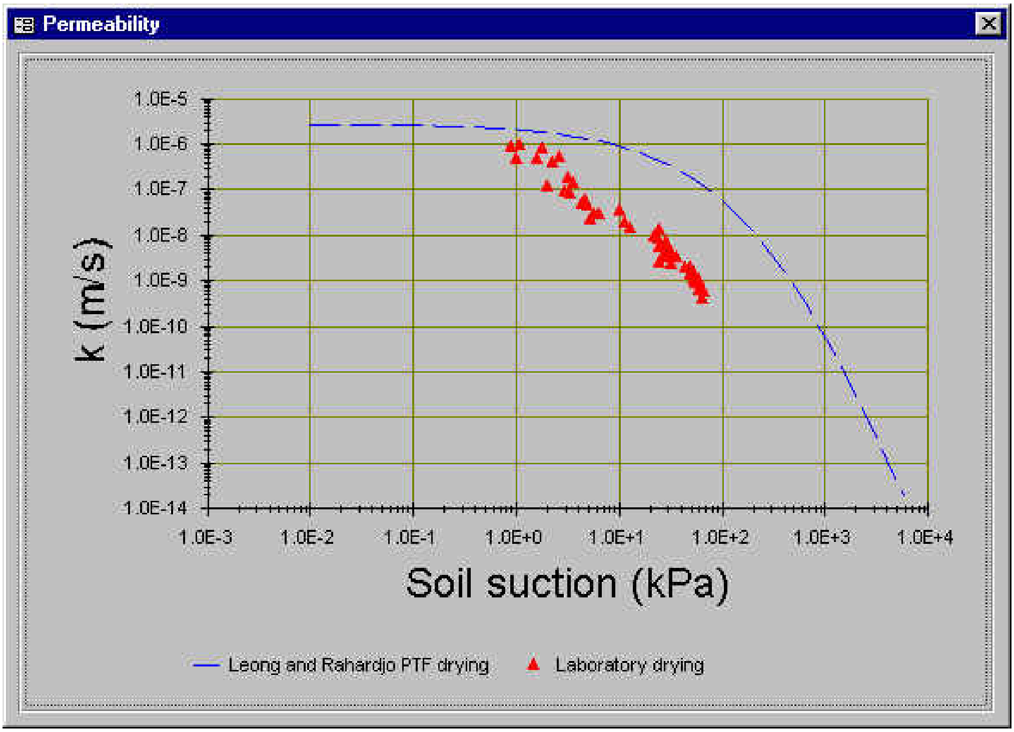
The **Leong and Rahardjo** estimation may be performed in a similar manner. The user first proceeds to the **Leong and Rahardjo** estimation tab.



The **Leong and Rahardjo** estimation requires the entry of the **Leong p** parameter (see above screen shot) as well as a **Leong Linked ksat** value prior to performing the estimation. An estimation of the possible variability of the **Leong p** parameter may be seen by clicking the **Help** button to the right of the **Leong p** field which will display the following normal distribution of **Leong p** values. The distribution presents an indicator of the possible variation for all soils.



After the user selects a **Leong p** value, they may proceed with the estimation by clicking the **Estimate** button. As with the **Fredlund and Xing** estimation, the results for the **Leong and Rahardjo** estimation can be viewed in the form of a graph via the **Graph** button.


Permeability
1.0E-5
1.0E-6
1.0E-7
1.0E-8
1.0E-9
1.0E-10
1.0E-11
1.0E-12
1.0E-13
1.0E-14
k (m/s)
1.0E-3
1.0E-2
1.0E-1
1.0E+0
1.0E+1
1.0E+2
1.0E+3
1.0E+4
Soil suction (kPa)
Leong and Rahardjo PTF drying
Laboratory drying

3 COMPARING DATA TO THE DATASET OF 6000 SOILS

The SoilVision dataset of highly detailed unsaturated information on over 6000 unsaturated soils allows the user to compare existing data to laboratory data. This comparison is often valuable in providing the user with an idea of the reasonable variation in the soil-water characteristic curve or permeability curve that can be expected. The following sections outline how SoilVision can be used to select groups of soils and plot variational indicators.

The user must be attached to the SVSoils_Data database for the following section. Please refer to the User's Manual for directions on how to open the SoilVision dataset.

3.1 SOIL-WATER CHARACTERISTIC CURVE

The SWCC is central to the behavior of the unsaturated soils. Estimation of the soil-water characteristic curve is critical to the proper modeling of transient seepage problems. The following sections outline several methods by which the SoilVision dataset mat be used to determine the possible variation of a SWCC using laboratory measured data.

3.1.1 Plotting Similar Soil-Water Characteristic Curves

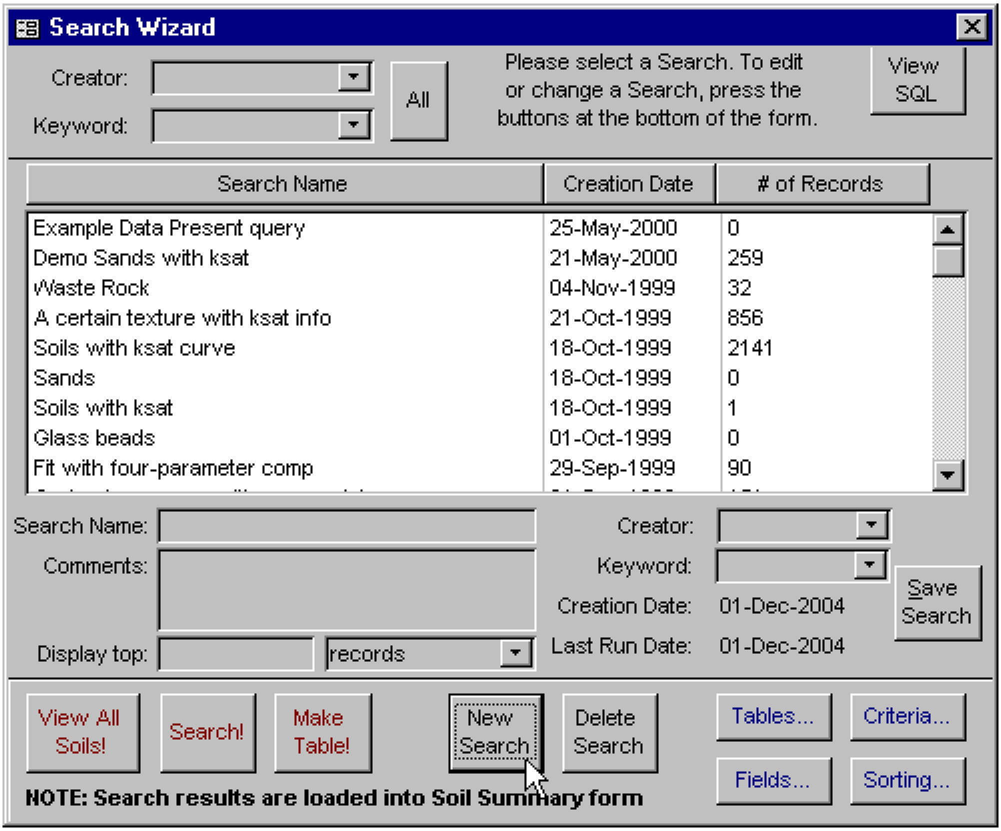
The method represented in the following sections allows for significant flexibility in the selection of similar SWCCs. Virtually any criteria that the user desires may be used to select a group of soils. For example, similar soils may be selected based on textures, grain-size distributions, Atterberg limits, or a range of insitu volume-mass properties. For this example, we will generate a plot of laboratory SWCC data with the following criteria:

USDA Texture	= "Sand"
No. of SWCC lab points	> 3
Porosity	between 0.3 and 0.4
Saturation	> 90%

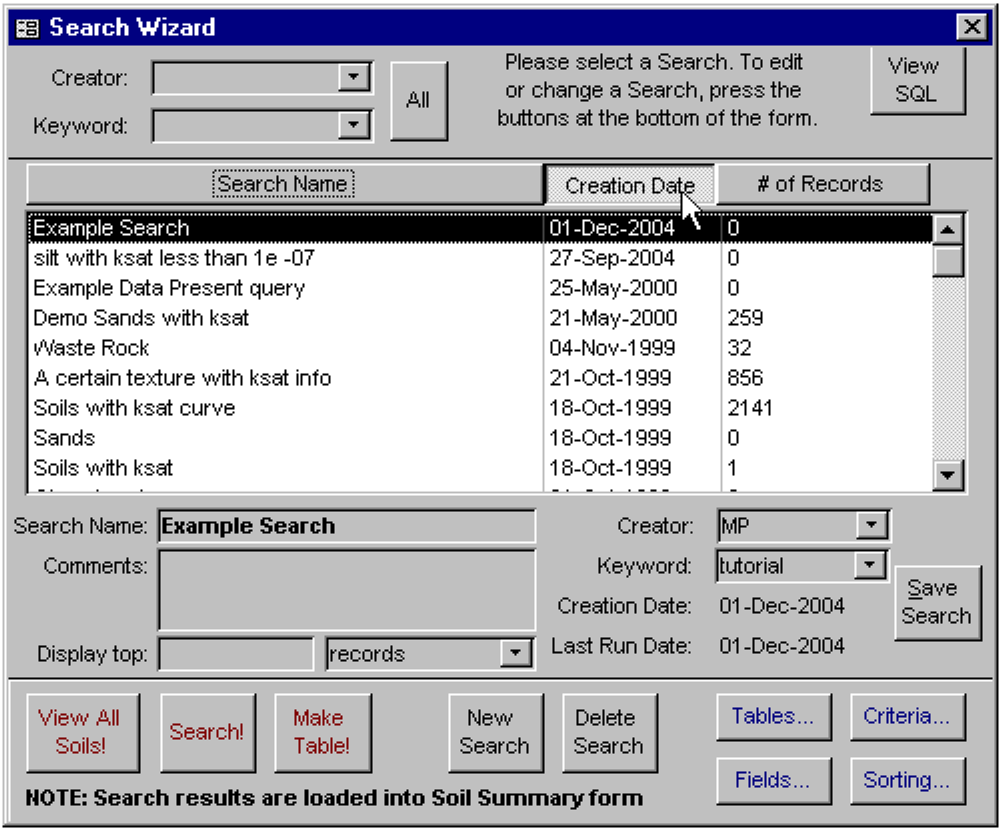
The user must first connect to the SVSoils_Search_A database, after which the user can access the **Search Wizard** through the main toolbar providing the **Soil Summary and Searching** form is current.

After the Search Wizard has been opened a new search can be created with the following steps:

1. A new search may be entered by pressing the New Search button at the bottom of the Search Wizard form.



2. A search name, creator, and keyword may then be entered into their respective fields in the Search Wizard form. The user may then click the Creation Date button to bring the new search to the top of the list.

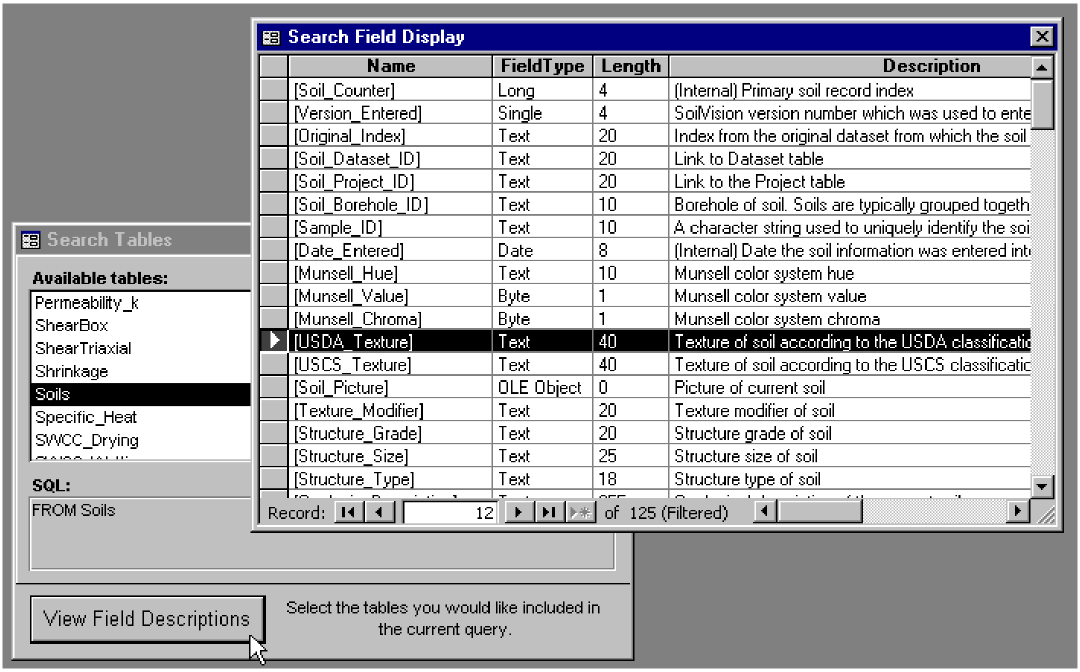


3. The user must then proceed to the Search Tables form (accessed through the Tables button on the Search Wizard form). For our example, we will have to select 4 tables in accordance with our 4 criteria (USDA Texture, No. of SWCC lab points, Porosity, and Saturation). The primary question becomes: “How do we find the table that contains the fields we desire to search?” For example, what table contains the USDA texture field? There are two methods for identifying tables:

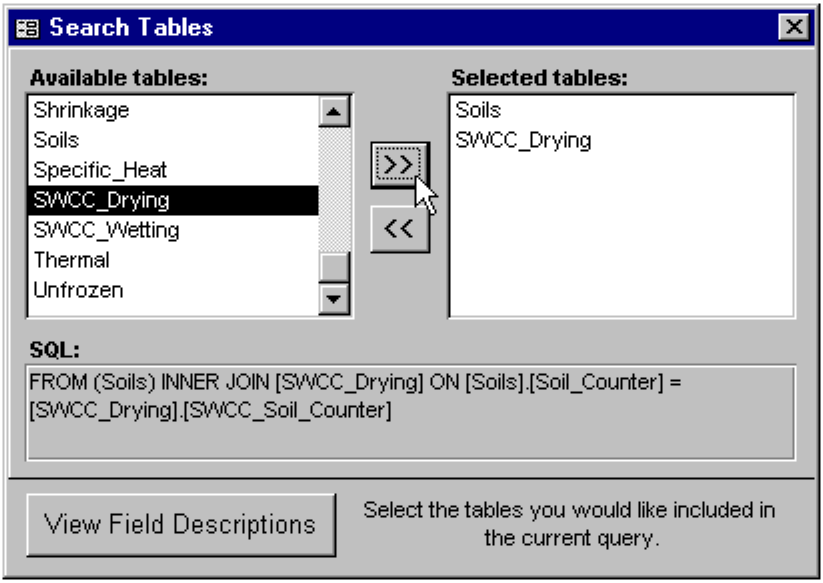
    i. Each table in SoilVision corresponds to a particular form. For example, the Soils form displays the fields contained in the Soils table. The form name and table name are not always identical, however, but may be matched up through the following matching table. The form names (with the exception of Soils) correspond to the buttons on the **Properties** tab of the **Soils** form.

Form Name	Table Name
Grain-size	Grainsize
Wetting SWCC	SWCC_Wetting
Drying SWCC	SWCC_Drying
Triaxial Compression	Compression_Triaxial
Oedometer Compression	Compression
Unfrozen Water Content	Unfrozen
Volumetric Specific Heat	Specific_Heat
Thremal Conductivity	Thermal
Direct Shear	ShearBox
Shear Triaxial	ShearTriaxial
Saturated Permeability	Permeability_k
Unsaturated Permeability	Permeability
Permeability vs. Void Ratio	kVoid
Diffusion	Diffusion
Geochemistry	Geochemistry
Shrinkage	Shrinkage
Compaction and CBR	Compaction
Soils	Soils

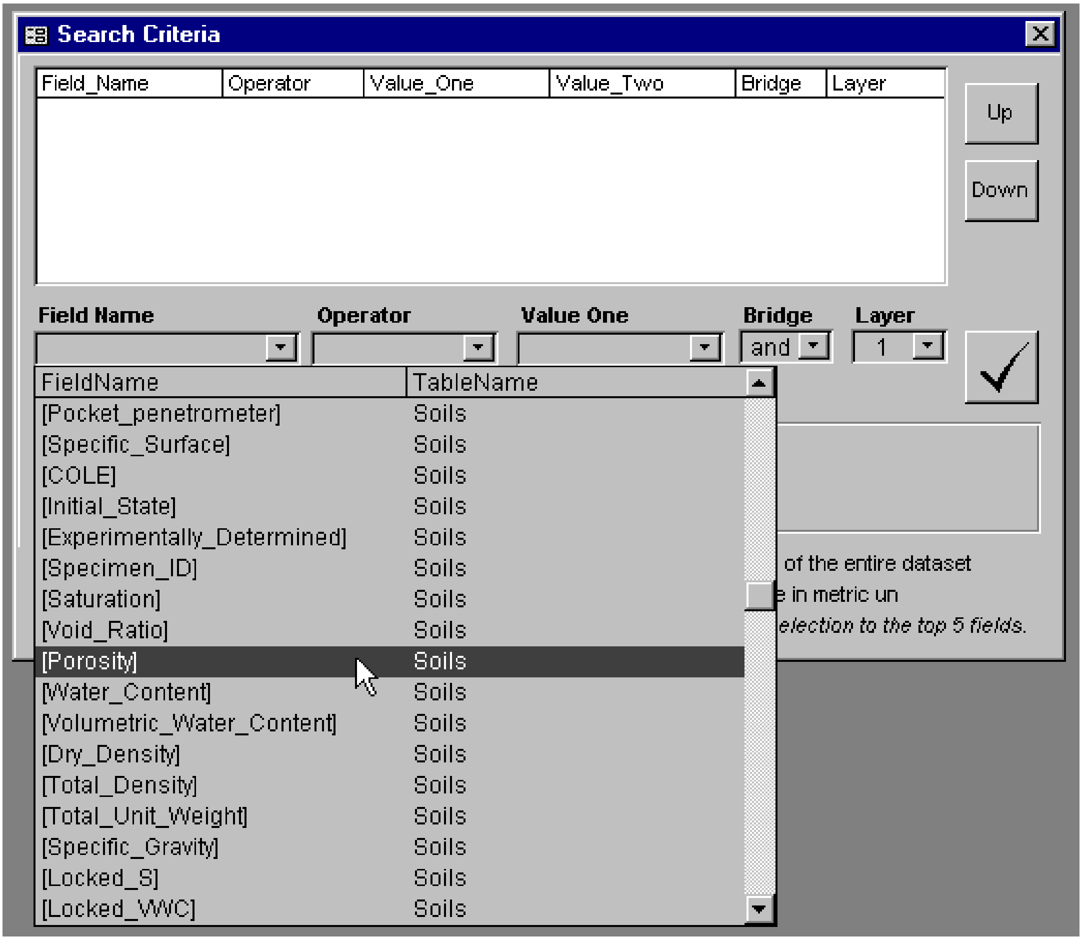
ii. The user may search through the list of fields contained in each table by pressing the **View Field Descriptions** button. For example, if we click on “Soils” in the **Available Tables** list and then press **View Field Descriptions** we will see the field **USDA_Texture** listed. We therefore know that the Soils table must be included in our search.



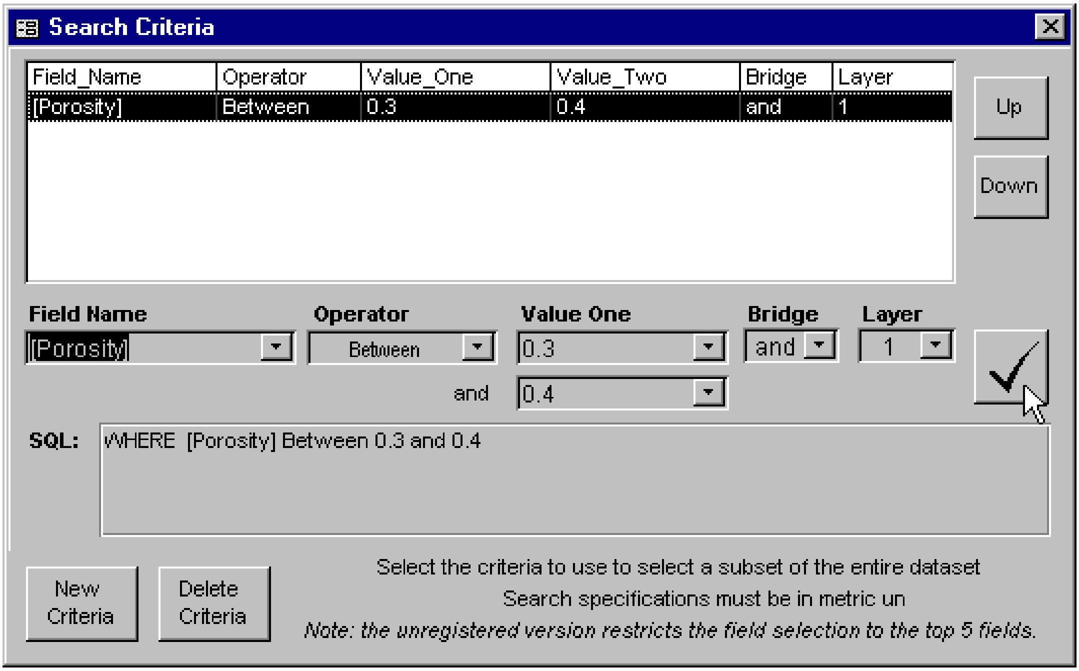
In our case, our first criteria involves the **USDA Texture** field which is found within the **Soils** table as mentioned previously. The user may wish to consult Appendix A: Search Table Field Descriptions to aid in the location of field names and their respective tables. Once all of the fields have been located, the associated tables can be selected by pressing the **>>** button on the **Search Tables** form. The user should not select more than three tables as there is a limit on the total number of fields which may be included in a query. In our case, **USDA Texture**, **Porosity**, and **Saturation** were all found within the **Soils** table while the **No. of SWCC laboratory points** was contained within the **SWCC Drying** table. Both tables have been selected as shown below.



4. The user may then proceed to the **Search Criteria** for which can be accessed via the **Criteria** button on the **Search Wizard** form. Here the user enters the details of each of the criteria involving fields contained in tables selected in the **Search Tables** form.



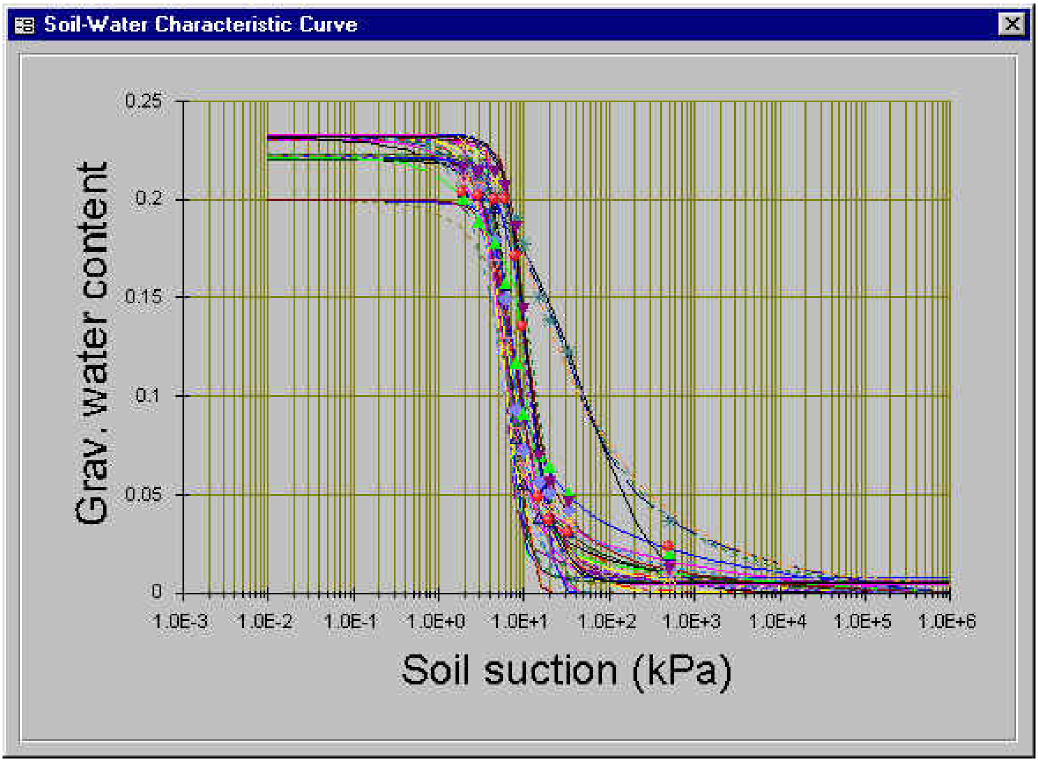
The user will notice that when selecting the Field Name from the drop-down, only the Fields from the selected tables will be available for selection. When entering the rest of the fields, the user simply matches the fields to the criteria parameters. When one of the criteria has been entered, it is stored in the list by clicking the “check mark” button. The user may enter new criteria by clicking the **New Criteria** button. Shown below is the proper entry of our Porosity criteria.



5. When all criteria has been entered, the user may then go back to the **Search Wizard** form and run the query by clicking the **Search!** button. The soils meeting the criteria in the current search will then be selected in the Soil Summary and Searching form. (The **Sorting** form is optional when running searches.)

Once the search has been run, the next step involves plotting of the group of soil-water characteristic curves. Plotting all curves selected in the current search may be accomplished through the options of the **SWCC Graph Wizard** can be accessed through the **Graph** button on the main toolbar when the **SWCC Drying** form or the Soil **Summary and Searching** form is current.

Please see the **SWCC Graph Wizard** section of the User's Manual for a complete description of the **SWCC Graph Wizard**. Once the proper options have been selected under the **SWCC Graph Wizard**, the following plot will be produced.



3.1.2 Estimating Packing Porosity for the Fredlund and Wilson Estimation

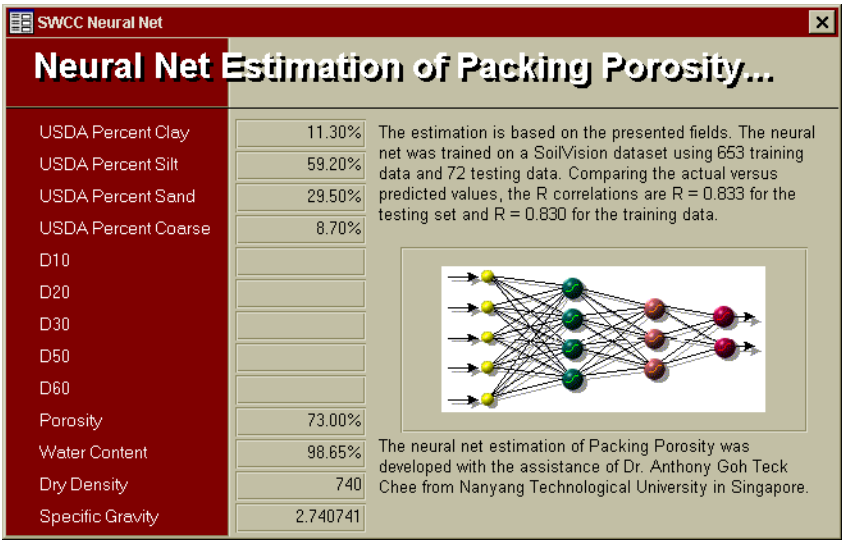
The soil-water characteristic curve is very important for modeling behavior of unsaturated soils. It may be imperative in certain situations to have increased accuracy in the estimation of the soil-water characteristic curve. A user may want a very reliable estimation of the soil-water characteristic curve from SoilVision without experimentally measuring the complete soil-water characteristic curve. A method is presented below to provide the user with the best estimate of the soil-water characteristic curve possible with SoilVision.

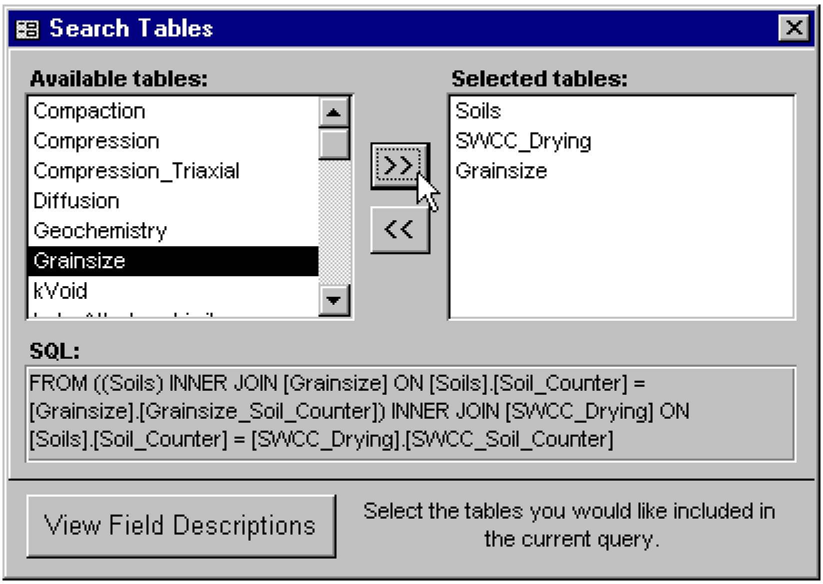
Basic soil information required is as follows:

3 volume-mass properties (i.e., Specific Gravity, Dry Density, and Water Content)
Well-defined grain-size distribution curve

The above information can be input into SoilVision and the remaining volume-mass properties automatically calculated. Once the grain-size information is input, a curve can be fit to the data and the soil can be classified (Texturally) by the USDA method. For the sake of this example, we will assume that we are dealing with a soil that has a “Sandy Loam” USDA textural classification and a porosity of 0.5.

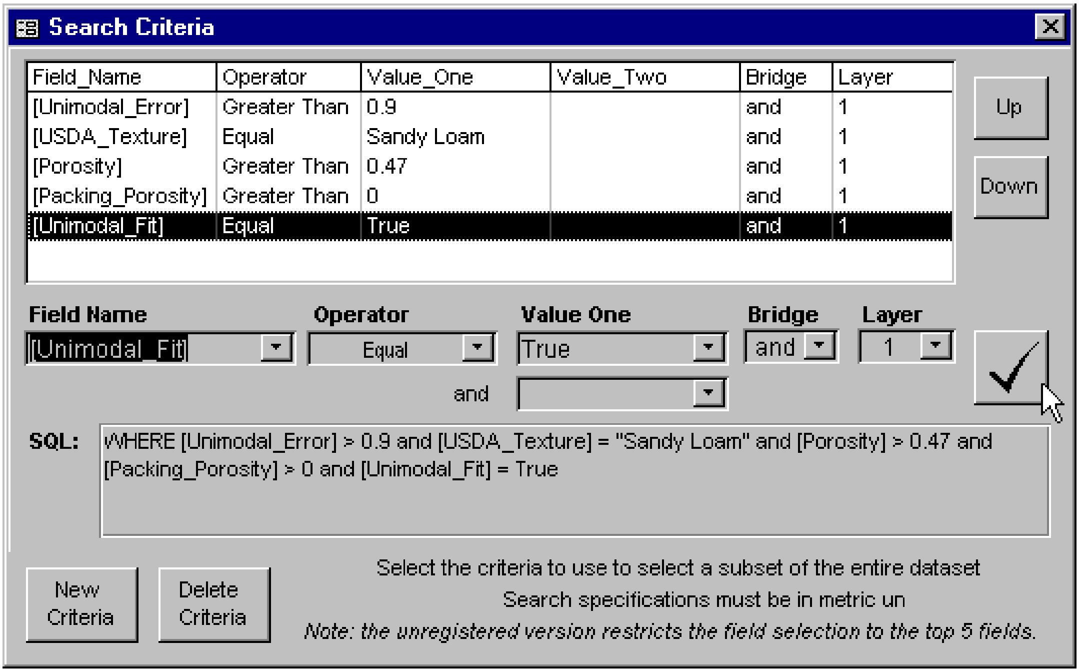
At this point, SoilVision will allow the user to estimate the soil-water characteristic curve from the grain-size distribution. To do this, however, an estimate of the **Packing Porosity** field is required. The **Neural Net** button next to **Packing Porosity** can be pressed to give an estimation of the **Packing Porosity** for the current textural classification.





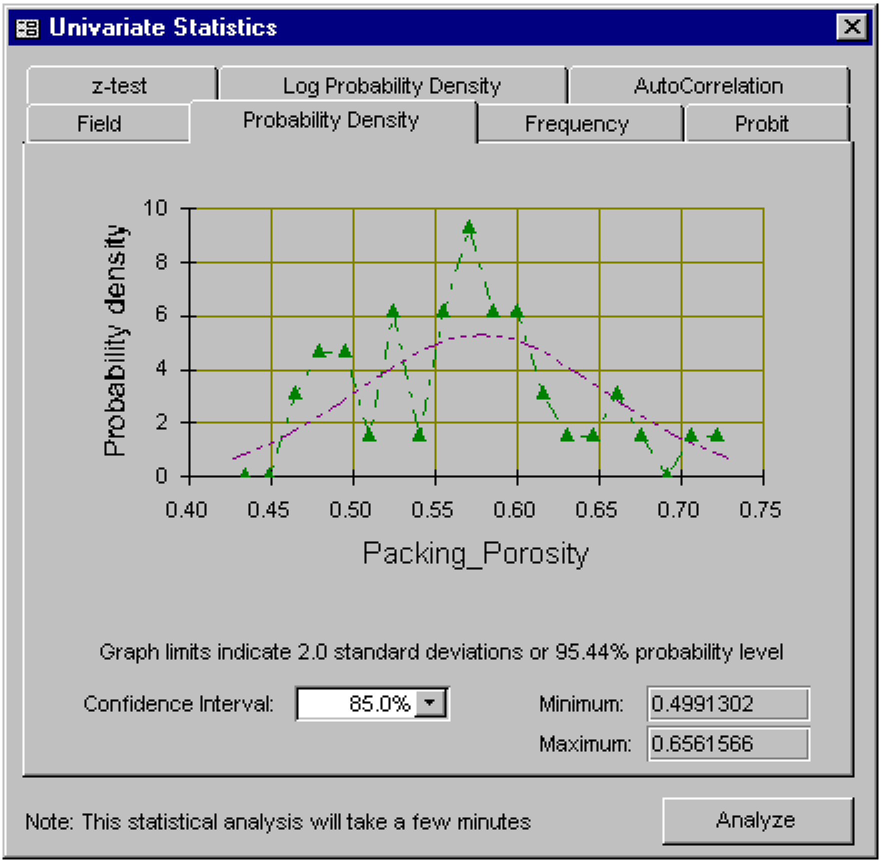
SoilVision implements a neural net estimation of the packing porosity. A neural net is an artificial intelligence (AI) learning method that utilizes a net of interconnected nodes each of which may be trained. The neural net implemented in SoilVision was implemented by training the neural net with a subset of the SoilVision dataset. The fields the neural net uses to determine a packing porosity are displayed in the neural net form.

Another method of obtaining an estimate of the **Packing Porosity** is to plot a frequency distribution with the help of the univariate statistics module. Generating the frequency distribution must first begin with the creation of a search which selects a desired group of similar soils. The criteria for selecting a group of soils with the same texture as the current soil is as follows:



Texture	= “Sandy Loam”
Grain-size Fit	= True
Grain-size Error	> 0.90
Porosity	< 0.47
Packing Porosity	> 0.0

A new search may be created using the Search Wizard with the following selection of tables and criteria.



The resulting frequency distribution for **Packing Porosity** is shown in the following figure. The narrowed distribution for **Packing Porosity** allows for reasonable estimation of the soil-water characteristic curve but this may not be accurate enough in certain situations.

The grain-size distribution primarily controls the shape of the predicted soil-water characteristic curve. The predicted shape of the soil-water characteristic curve has shown good correlation to the measured shape of the soil-water characteristic curve. In other words, the match between predicted and measured shape of the soil-water characteristic curve is often reasonable. Most variance between predicted and measured results can be attributed to the **Packing Porosity**. The **Packing Porosity** causes the predicted results to vary as shown in Figure 1. It can be seen that the **Packing Porosity** primarily causes the predicted curve to move horizontally on the graph of water content versus soil suction.

It is important to note that the packing porosity stored in the grain-size form does not necessarily have any relation to the Porosity of the soil. The **Packing Porosity** is a factor used to control the algorithm that builds the estimated soil-water characteristic curve from the grain-size distribution. As such, a definite correlation between **Packing Porosity** and Porosity has not been found.

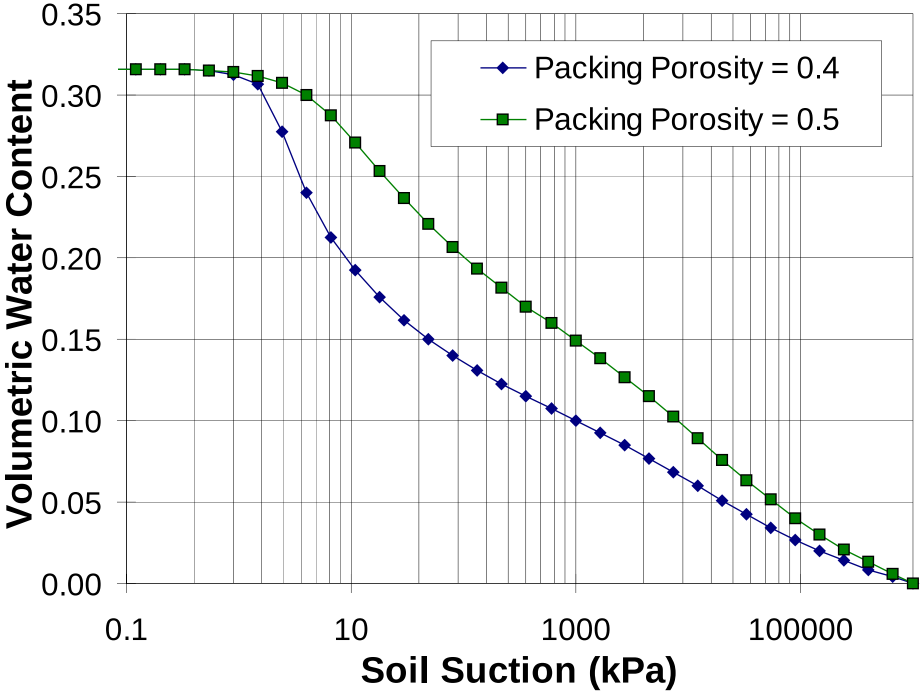


Figure 1 Variation of soil-water characteristic curve with different packing porosities for a Sandy Loam

Obtaining one, two, or three measured points on the soil-water characteristic curve would greatly improve the predicted results. These measured points would allow the **Packing Porosity** field to be trained or 'calibrated' to allow the highest precision in predicted results. A similar method for predicting the soil-water characteristic curve has been presented in research (Williams, 1985). SoilVision presents this prediction technique to allow the most accuracy possible without obtaining a fully measured curve.

The final soil-water characteristic curve can then be confidently implemented in the analysis of unsaturated soils.

3.2 PERMEABILITY

The SoilVision Dataset is one of the most comprehensive collections of unsaturated soil data currently collected. The dataset contains ksat information on over 2500 soil samples as well as unsaturated conductivity curves for over 400 soil samples. The following sections outline how to get value from your data.

3.3 STATISTICAL ESTIMATION OF KSAT

The SoilVision dataset contains ksat laboratory data on over 2500 soil samples. This dataset provides a valuable resource for allowing the user to get a feel of the possible variation of a particular ksat value. The laboratory ksat values are organized by soil texture and often also have related grain-size information. The

following sections outline methods by which the user may determine the statistical variation of ksat for a selected group of soils.

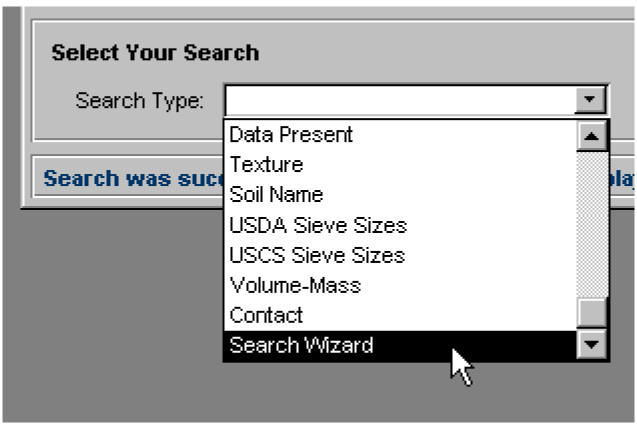
3.3.1 Confidence of ksat using Lognormal Distribution

It is useful when estimating saturated permeability to have an idea of the possible variance of the measurements. Most theoretical estimates of saturated permeability provide the user with a single value. It is often of more value to know the confidence we can place in this value. This section outlines a method of calculating confidence limits on the saturated permeability for a USDA classified “Sandy Loam”.

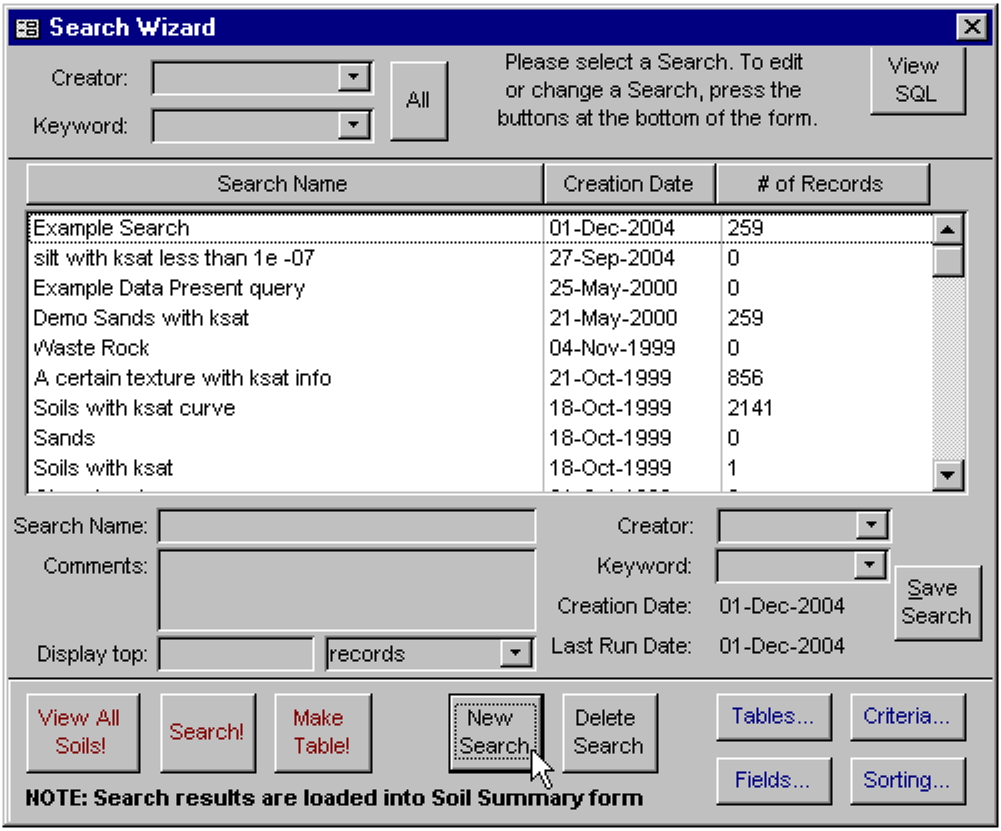
A lognormal distribution is required for calculating confidence limits for saturated permeabilities. A lognormal rather than a normal distribution is used because saturated permeability varies on a logarithmic scale. SoilVision will automatically calculate the lognormal distribution and confidence limits in the Univariate statistics module. A procedure for generating lognormal distribution is as follows.

The first step in SoilVision is to create a Search that selects the group of soils in which we are interested. For this example we will select all soils with a USDA textual classification of “Sandy Loam”. Many other selection methods based on varying soil properties are possible in SoilVision.

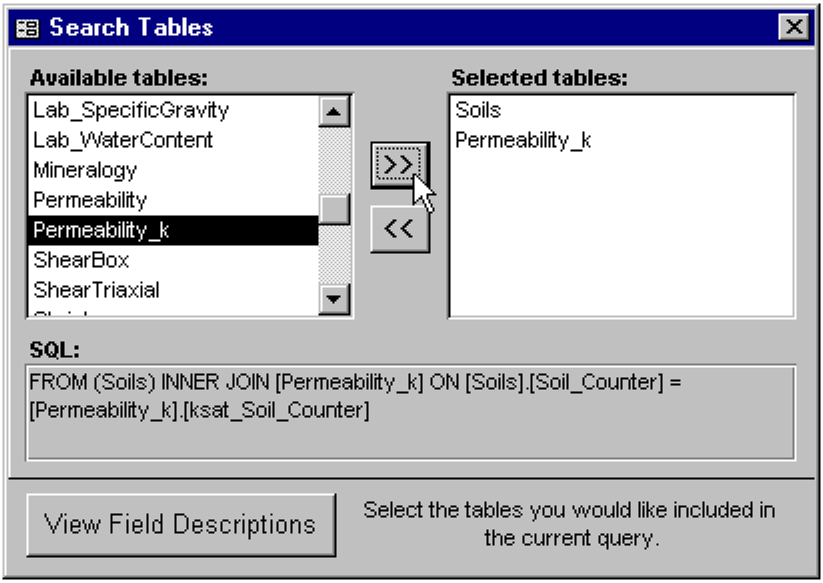
1. With the Soil Summary and Searching form current, the Search Wizard can be accessed through the main toolbar under the Search Button or through the Search Type combo box on the bottom of the form.



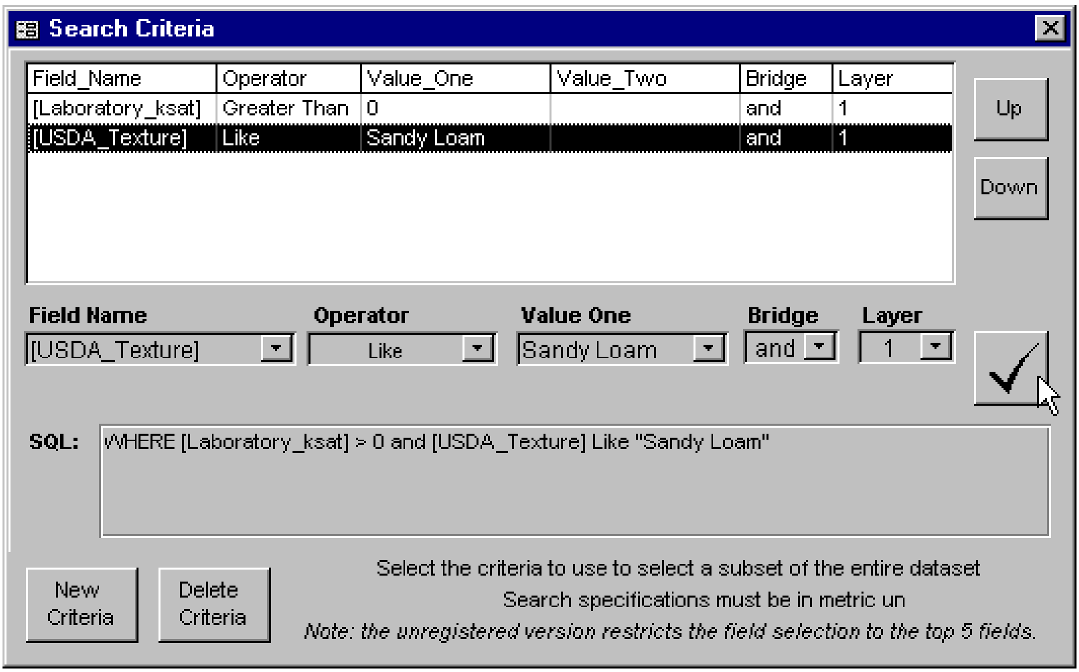
2. A new search can be initiated by pressing the New Search button at the bottom of the form.



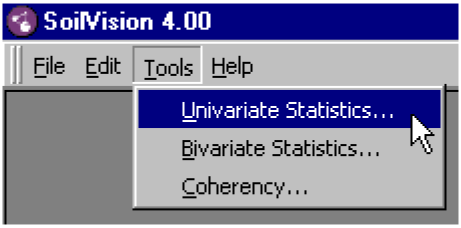
3. The user must then select the tables containing the field used in the criteria. Recall previously that the USDA Texture, our criteria in this case, is located in the Soils table in the Search Tables form. We must also add ksat to our field as that is the variable we are analyzing. The Field name for ksat is [Laboratory_ksat] and is contained within the Permeability_k table in the Search tables form. It should be noted that all ksat information is contained within the Permeability_k table. The user may enter the Search Tables form through the Tables button on the Search Wizard form and select the Soils and Permeability_k tables with the >> button.



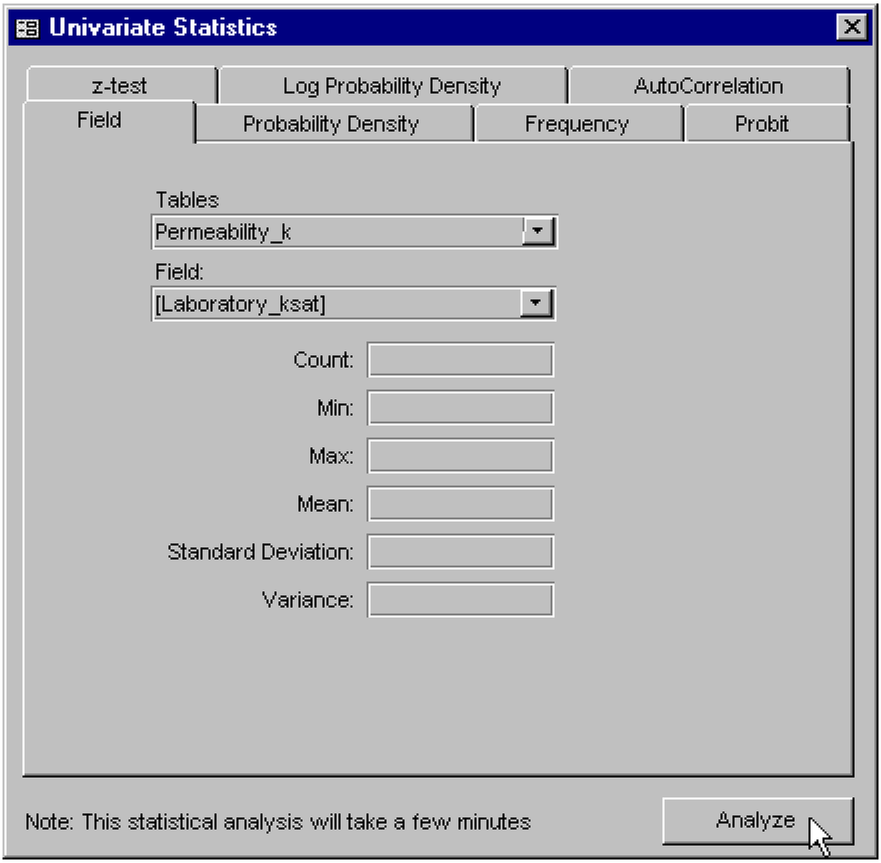
4. Next, the user should proceed to the Search Criteria form accessed through the Criteria button on the Search Wizard form. The user then fills in each field from left to right for both the USDA Texture and Laboratory ksat fields. When finished, the user clicks the "check mark" button to enter the criteria.



5. Once the search has been created, the Univariate Statistics module may be found under the Tools menu, providing the Search Wizard window is current. It should be noted that the search does not need to be run before accessing the Univariate Statistics module.

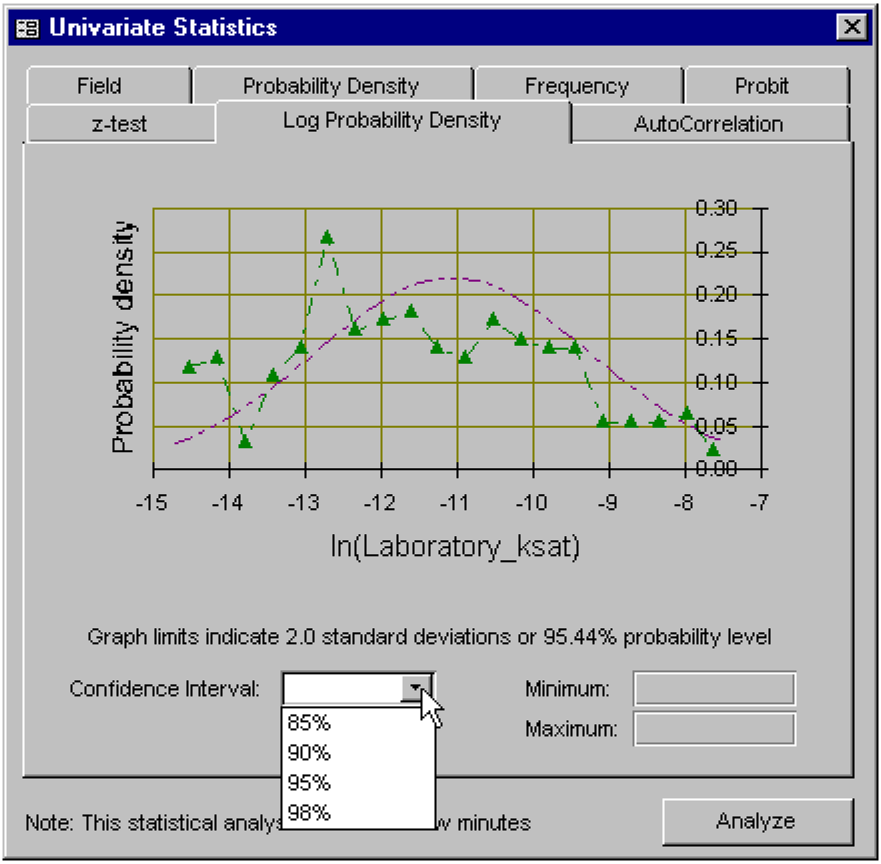


6. Once the Univariate Statistics window has been opened, the user must enter the proper information into the Table and Field fields of the Field tab. This information will correspond to the table and field with respect to the variable being analyzed. In our case the Permeability_k table and the [Laboratory_ksat] field are selected.



7. The user does not need to enter any further information on any of the other tabs in the Univariate Statistics window. The user may then click the Analyze button to begin the calculations.

Calculations may take some time. All computations are finished when the mean, variance, etc have been calculated and are displayed on the **Field** tab of the **Univariate Statistics** form. The results of the lognormal distributions may be seen by clicking on the **Log Probability Density** tab. The graph presents the distribution of the data compared to the lognormal distribution fit of the data. It should be noted that the user may only run statistics on numeric fields. The lognormal probability distribution graph is the most significant since ksat varies on a logarithmic scale. Confidence limits may now be calculated by selecting values in the field at the bottom of the form.



Similar statistics can be generated for any other numeric field stored in the SoilVision database.

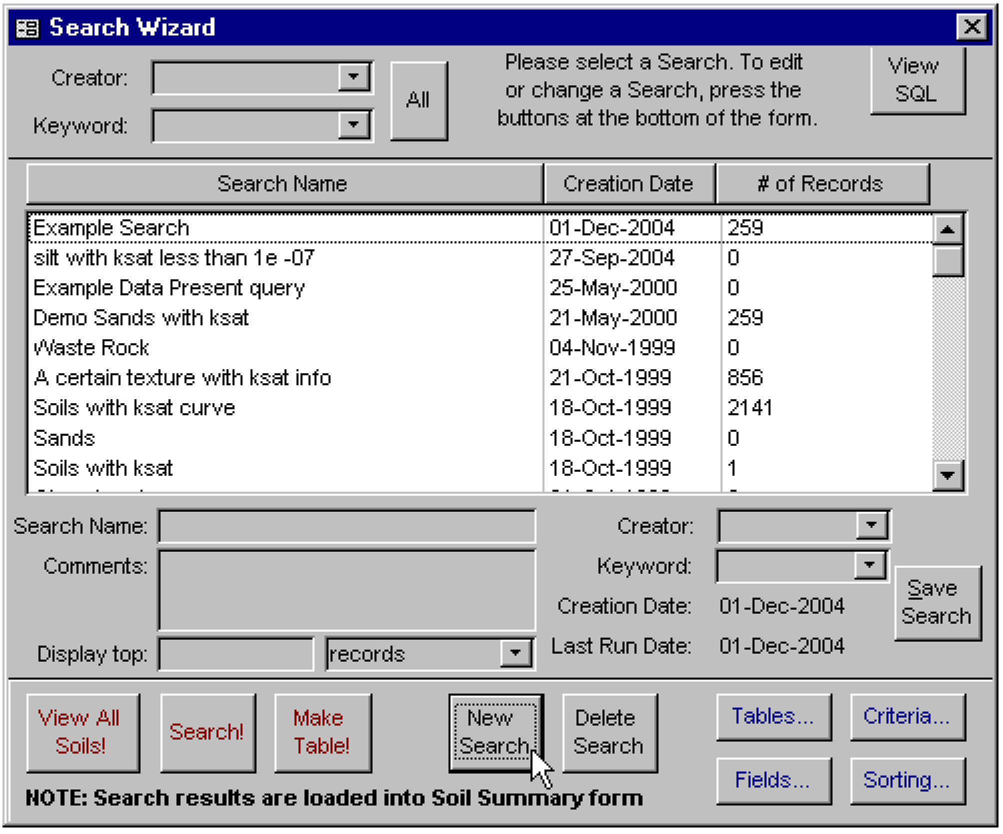
3.3.2 ksat Estimation Confidence

One useful application of the SoilVision dataset is to evaluate the performance of a particular estimation method against experimented data.

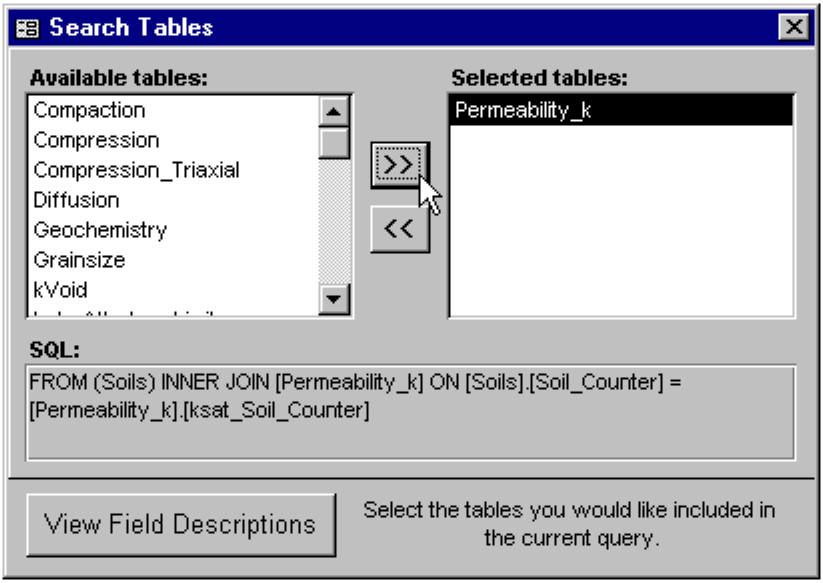
Most estimation methods for saturated permeability are designed for soils dominated by sand sized particles. This example will therefore compare the performance of the Terzaghi estimation method against the laboratory measured saturated permeability of Sands.

What is desired is a plot of the estimated Terzaghi saturated permeability versus the laboratory saturated permeability of Sands. This plot may be provided using the statistics module of the SoilVision software. The steps involved are as follows:

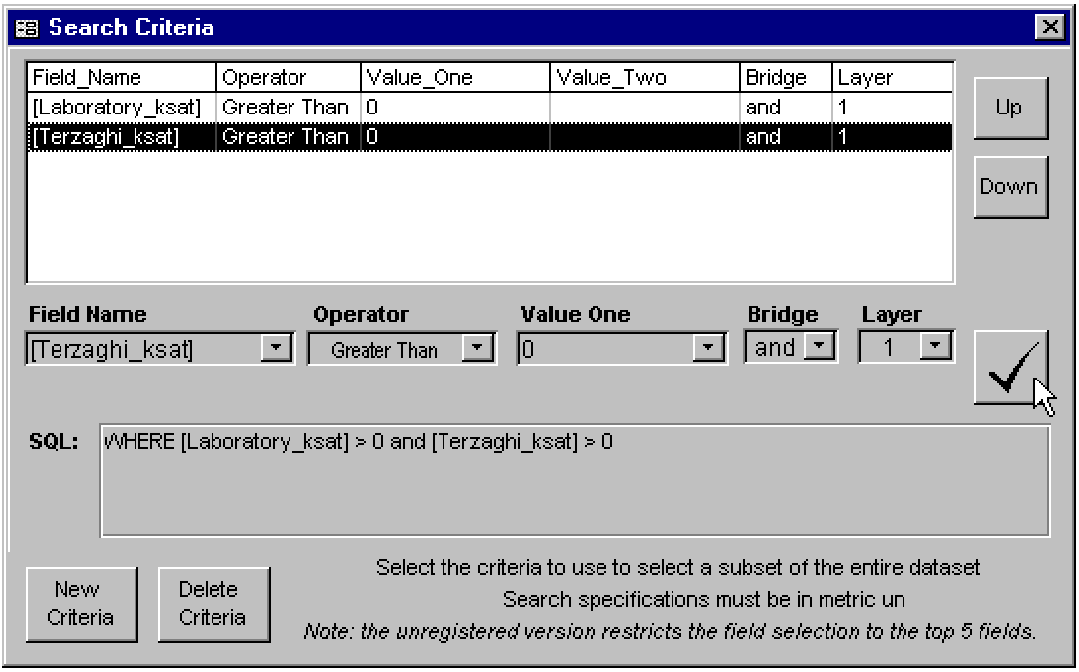
1. As with our previous two examples, the user must access the **Search Wizard** and create a new search with the **New Search** button.



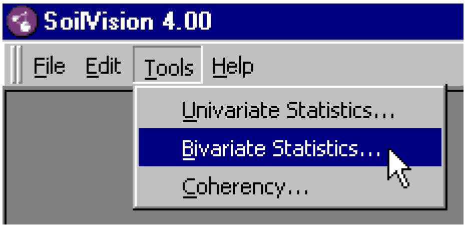
2. The user must then open the **Search tables** form and choose the **Permeability_k** table since both of our fields, **[Laboratory_ksat]**, and **[Terzaghi_ksat],** are contained therein.



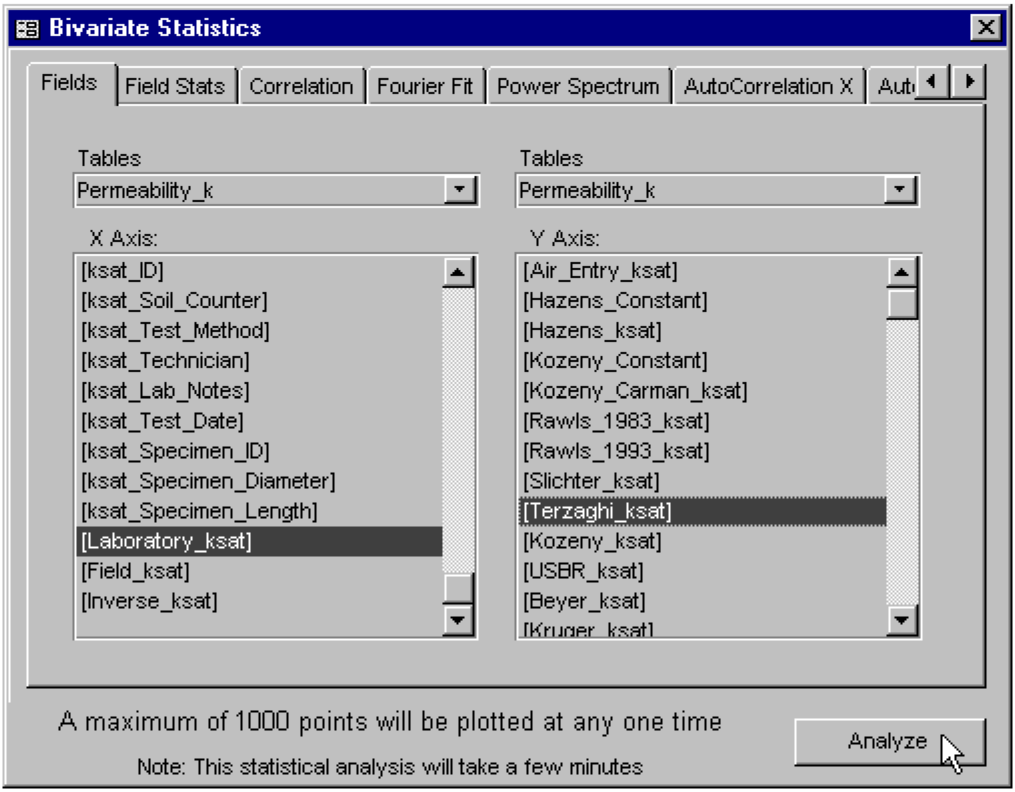
3. The user then accesses the Search Criteria form and proceeds to enter a criteria for both **[Laboratory_ksat]** and **[Terzaghi_ksat]** into their respective fields. The only criteria specified is that a value greater than zero be present for each field.



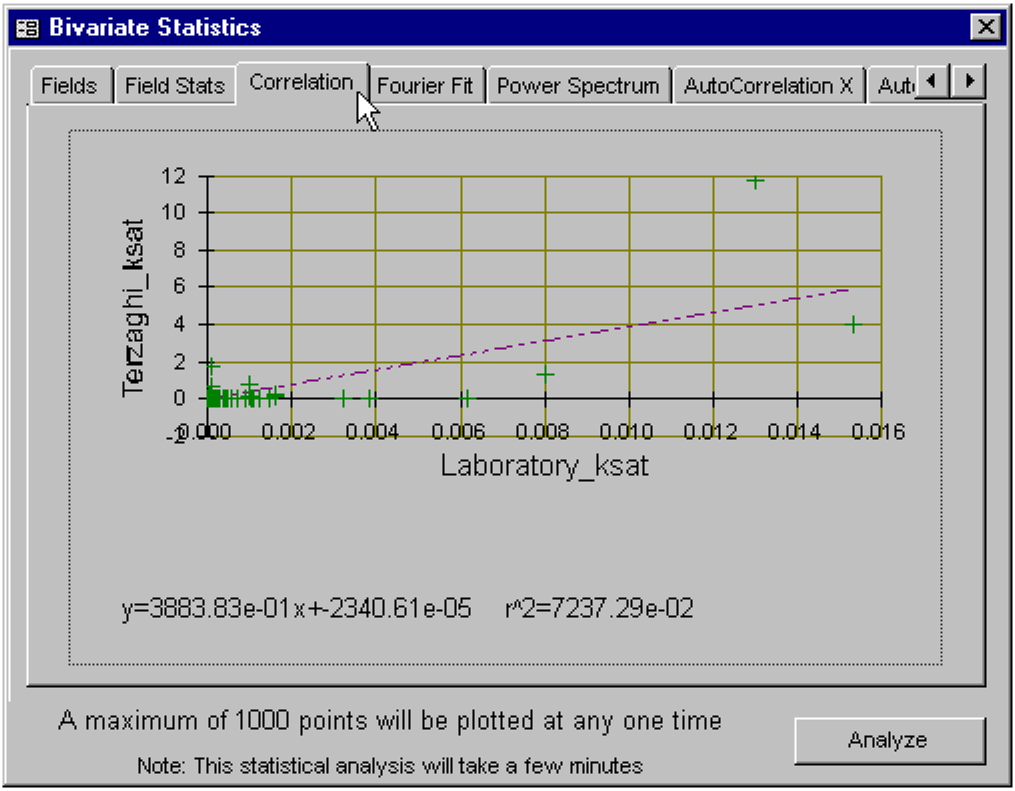
4. Once the search has been created, the user may then proceed to the **Bivariate Statistics** module located under the **Tools** menu of the **Search Wizard** window. As with our previous example, the new search does not need to be run to access and use the **Bivariate Statistics** module.



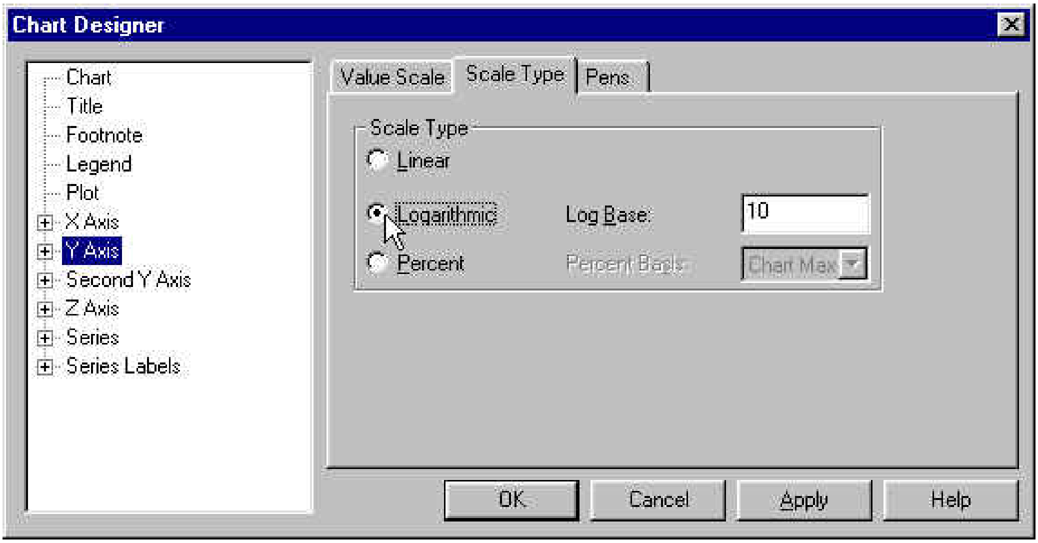
5. When the **Bivariate Statistics** form has been opened, the user will select **Permeability_k** for each of the table selections causing all field descriptions contained within the table to be displayed in the lists below. From these lists, which represent the X and Y axis, **[Laboratory_ksat]** will be chosen for the X-axis and **[Terzaghi_ksat]** chosen for the Y-axis. No other information entry is required in the **Bivariate Statistics** form. When the proper selections have been made, the user may begin the calculations by clicking the **Analyze** button.



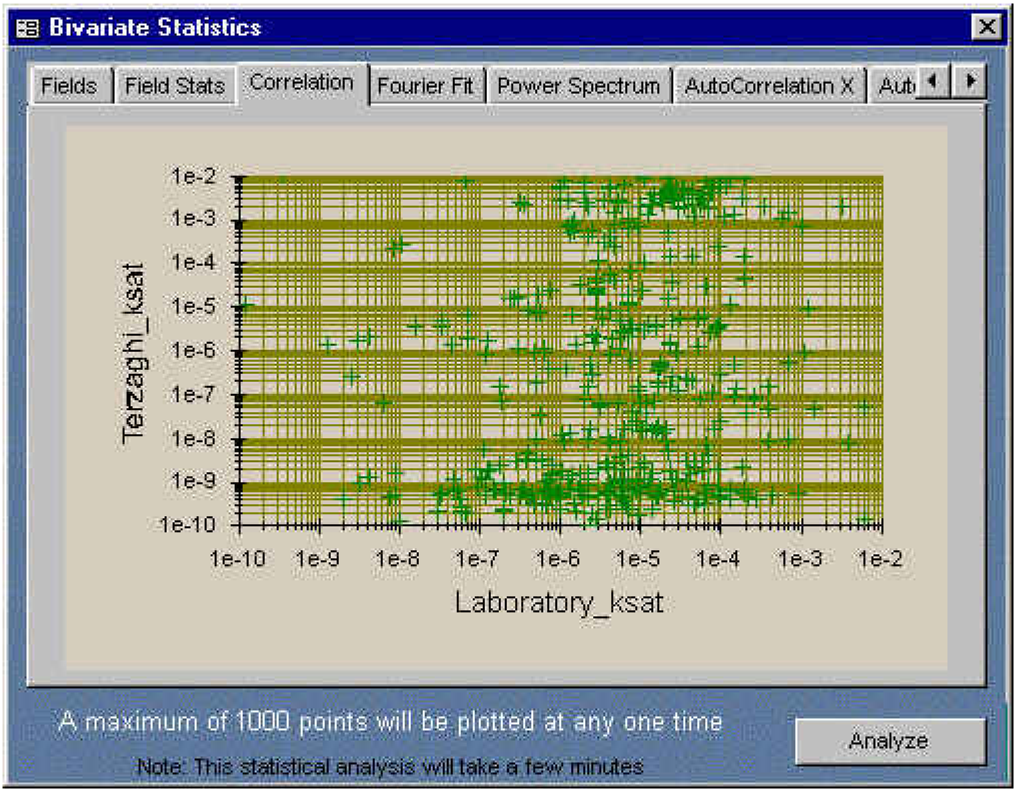
It will take a significant amount of time for SoilVision to generate the appropriate graphs. The calculations are complete when the graphs on the form are displayed. The graphs shown below will become available through the various tabs in the form.



Since conductivity varies on a log scale, it is more meaningful to change each axis to a log scale. This is accomplished by double-clicking each axis (to open the Chart Designer window), and selecting a logarithmic scale as shown below.



The final logarithmic comparison between laboratory ksat and the Terzaghi ksat for sands may be seen in the following screen shot.



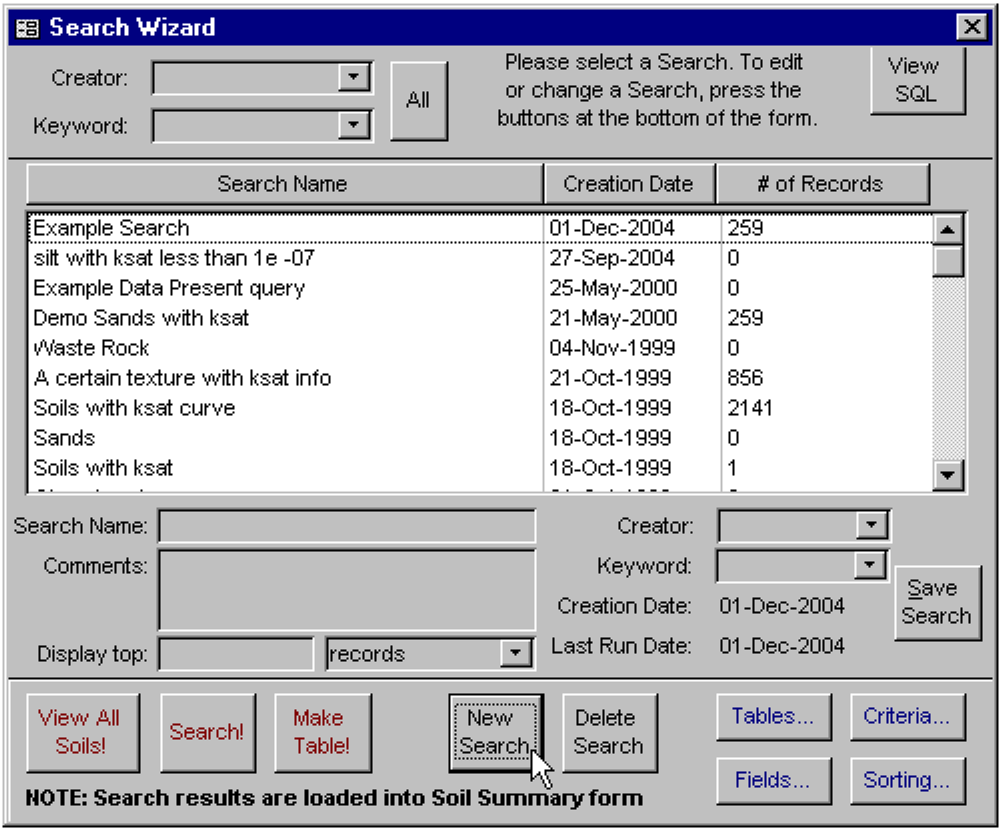
3.4 STATISTICAL ESTIMATION OF KUNSAT

The SoilVision dataset provides laboratory data on over 400 unsaturated hydraulic conductivity curves. It is possible to plot groups of these curves based on texture or grain-size properties to provide an estimate of the shape of the unsaturated permeability function. The method is outlined below.

Using the Search Wizard, we will first select a group of soils according to the following criteria:

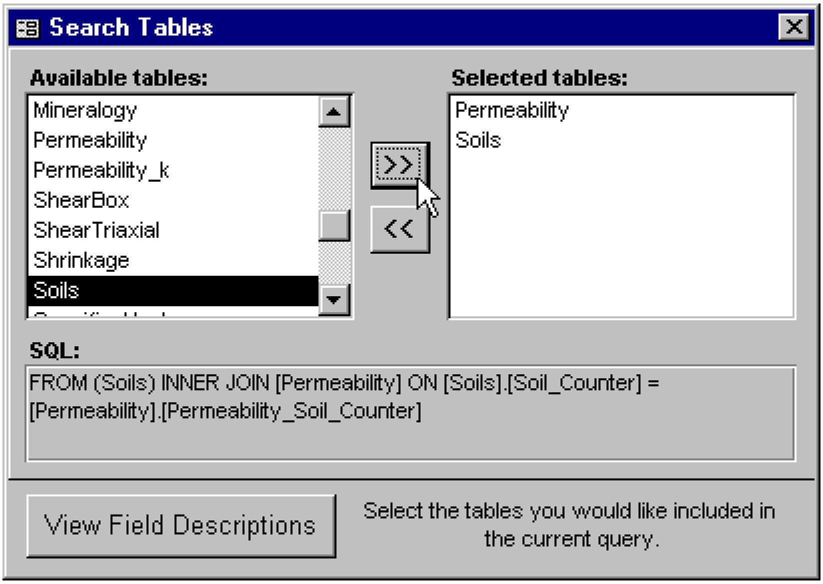
Porosity, n	0.3<n<0.4
Lab Permeability Count	>0
USDA Texture	Sand

1. As with our previous examples, the user must access the **Search Wizard** and create a new search with the **New Search** button.

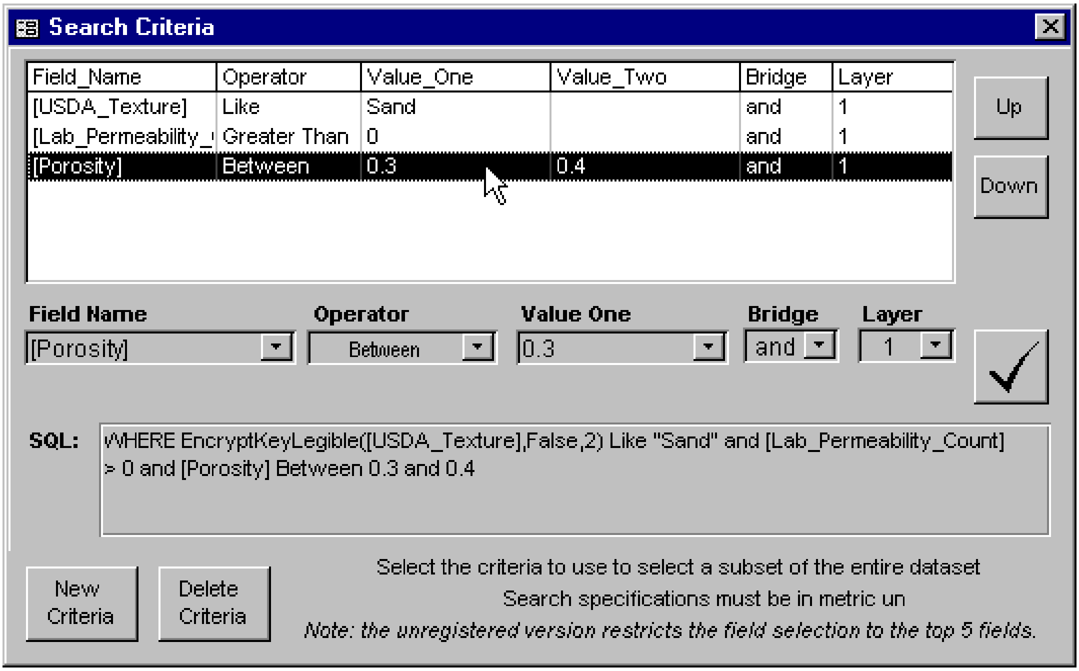


2. Once a new **Search Name**, **Creator**, and **Keyword** have been entered, the user must select the tables containing the field descriptions of the criteria desired. Recall previously that both the USDA Texture, and Porosity are located in the **Soils** table, while Lab Permeability Count is located in the **Pemeability** table. The user may enter the **Search Tables** form

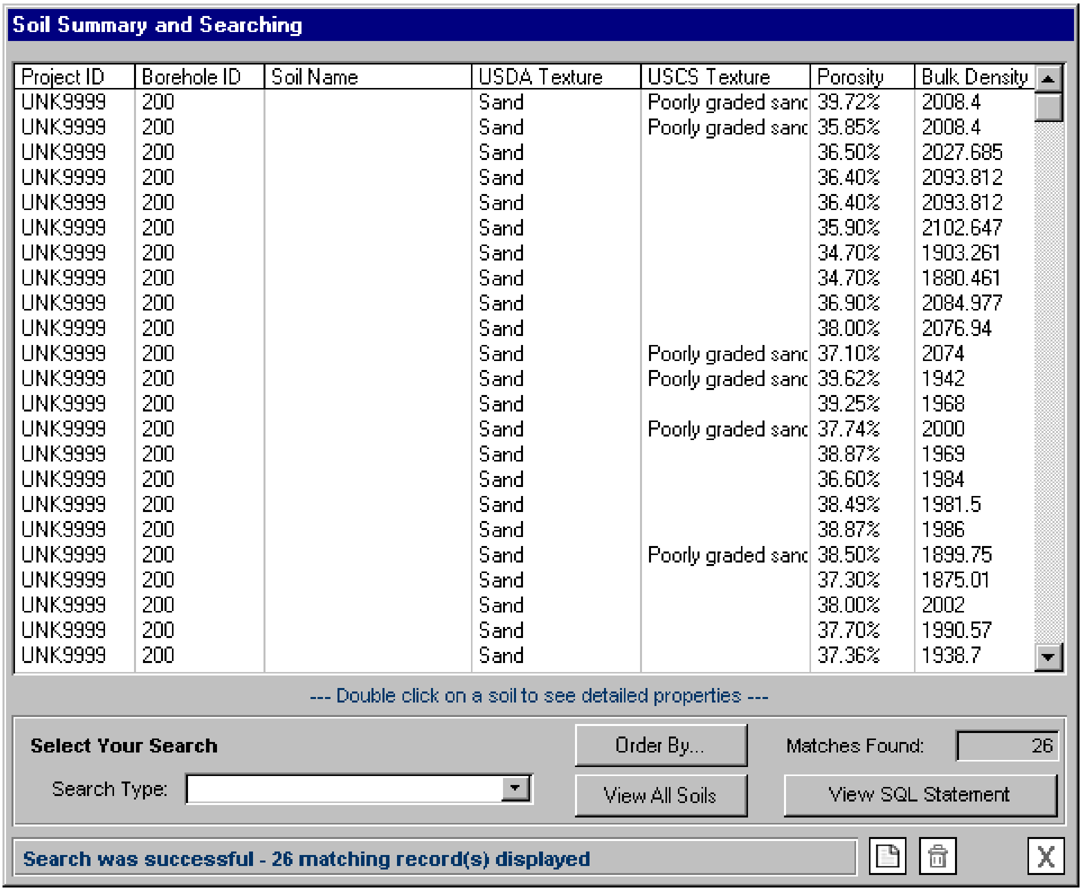
through the **Tables** button on the **Search Wizard** form and select the **Soils** and **Permeability** tables with the **>>** button.



3. Next, the user should proceed to the **Search Criteria** form accessed through the **Criteria** button on the **Search Wizard** form. The user then fills in each field from left to right for both the USDA Texture, Lab Permeability Count, and Porosity field descriptions. When finished, the user clicks the “check mark” button to enter the criteria.



4. The search is then initiated by pressing the **Search!** button at the bottom of the **Search Wizard** form. The results will be placed into the **Soil Summary and Searching** form.



The results should be a group of 26 soils that are now displayed in the **Soil Summary and Searching** form. Plotting the group of unsaturated permeability curves may be accomplished through the following steps:

1. Proceed to the **Properties** tab of the **Soils** form and click the **Unsaturated Permeability** button.

2. Once the **Unsaturated Permeability** form is current, select the **Permeability Graph Wizard** from the **Graph** menu on the main tool bar.

3. Once the **Permeability Graph Wizard** has been accessed it will prompt the user to make simple selections in a series of step. For our example, enter the following as prompted:

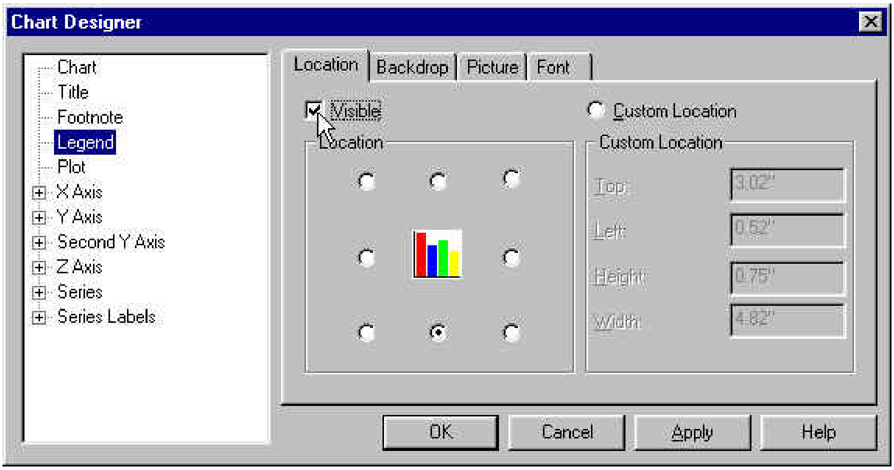
Step 1: Select “All soils in current query” and click **Next**.

Step 2: Select “Drying SWCC” and click **Next.**

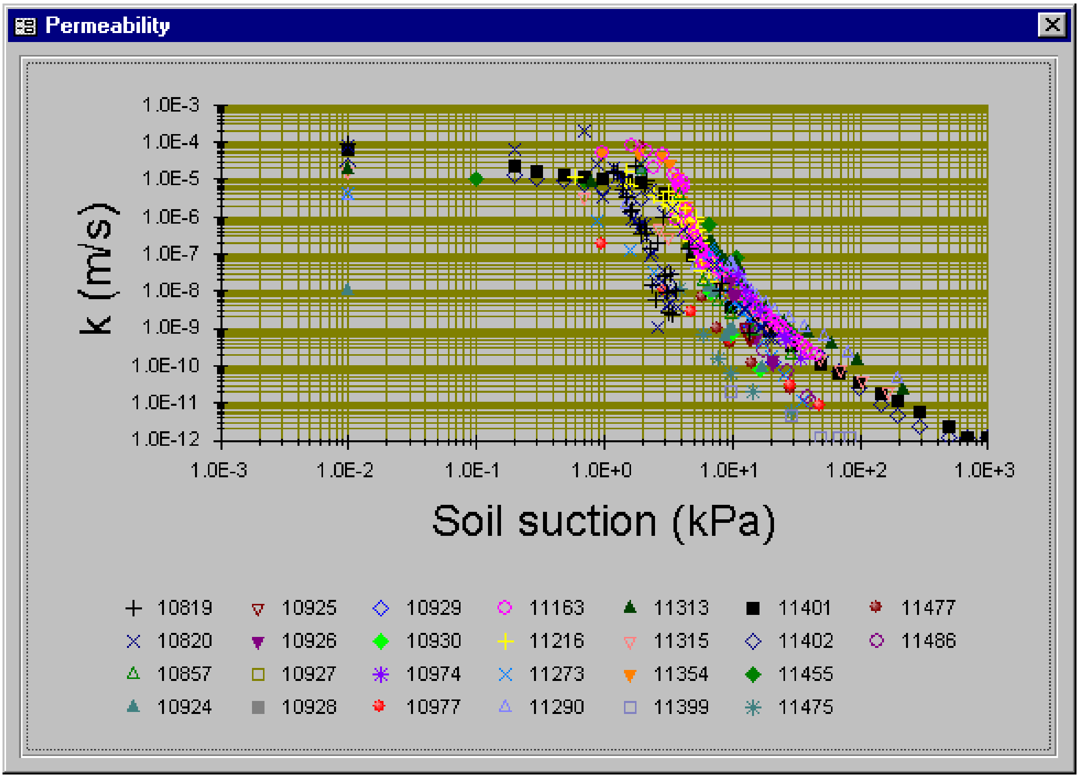
Step 3: Select “Experimentally measured lab data” and click **Next**.

Step 4: Select “Relative Permeability” and click **Next,** then click **Finish**.

4. Once the calculations are complete and the graph is displayed, double-click the Legend to open the **Chart Designer** window. The user should have the Legend section displayed and can then click the visibility box so that the Legend disappears. Close the **Chart Design** window.



5. Next, double-click the Y-axis (directly on the axis line) to again open the **Chart Designer** window now with the Y-axis section displayed. Select the **Scale Type** tab, select **Logarithmic** and click **OK**. The result should be the graph below.


Permeability
k (m/s)
1.0E-3
1.0E-4
1.0E-5
1.0E-6
1.0E-7
1.0E-8
1.0E-9
1.0E-10
1.0E-11
1.0E-12
1.0E-3
1.0E-2
1.0E-1
1.0E+0
1.0E+1
1.0E+2
1.0E+3
Soil suction (kPa)
10819
10820
10857
10924
10925
10926
10927
10928
10929
10930
10974
10977
11163
11216
11273
11290
11313
11315
11354
11399
11401
11402
11455
11475
11477
11486

Appendix A: Search Table Field Descriptions

Compaction			
Name	FieldType	Length	Description
[aq]	Single	4	(Internal) Parameter for the Quadratic equation
[bq]	Single	4	(Internal) Parameter for the Quadratic equation
[CBR_Dry_Density]	Single	4	Dry density of the soil sample (kg/m^3)
[CBR_Initial_State]	Text	50	Sample type used in the CBR test
[CBR_Remarks]	Text	255	Remarks regarding the CBR test
[CBR_Specimen_ID]	Text	20	ID for specimen used in test
[CBR_Total_Density]	Single	4	Average total density of soil sample (kg/m^3)
[CBR_Value]	Single	4	Results of the CBR test
[CBR_WC_After_Compaction]	Single	4	Gravimetric water content of the loose soil used for the CBR after compaction
[CBR_WC_Average_After_Soaking]	Single	4	Average gravimetric water content after soaking
[CBR_WC_Before_Compaction]	Single	4	Gravimetric water content of the loose soil used for the CBR before compaction
[CBR_WC_Top_After_Soaking]	Single	4	Gravimetric water content of the top 1 inch layer after soaking
[Compaction_Count]	Byte	1	(Internal) Number of experimental points on the compaction curve
[Compaction_ID]	GUID	16	(Internal)
[Compaction_Initial_State]	Text	10	Sample type origin used in test
[Compaction_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Compaction_Soil_Counter]	Long	4	Link to main soil properties table
[Compaction_Specimen_ID]	Text	15	ID for specimen used in test
[Compaction_Technician]	Text	50	Technician responsible for experimental results
[Compaction_Test_Date]	Date	8	Date lab test was performed
[Compaction_Test_Method]	Text	150	Test method used to obtain experimental results
[Compactor_Type]	Text	50	Type of compactor used to compress the soil
[Compactor_Weight]	Single	4	Weight of the compactor used on the soil (kN)
[cq]	Single	4	(Internal) Parameter for the Quadratic equation
[Li_Error]	Single	4	(Internal) R squared difference between experimental data and the Li fit
[Li_Fit]	Boolean	1	(Internal) Has the Li equation been fit to data?
[Li_Maximum_Dry_Density]	Single	4	(Internal) Maximum Dry Density for the current soil as determined by the Li fit (kg/m^3)
[Li_n]	Single	4	(Internal) Fitting parameter

[Li_Optimum_Water_Content]	Single	4	(Internal) Optimum water content for the current soil as determined by the Li fit
[Li_p]	Single	4	(Internal) Fitting parameter
[Li_Sm]	Single	4	Maximum degree of saturation when soil is prepared and compacted well wet of its optimum moisture content
[Li_wm]	Single	4	(Internal) Water content when Sm is achieved
[Maximum_Dry_Density]	Single	4	(Internal) Maximum Dry Density for the current soil as determined by the Quadratic fit (kg/m^3)
[Optimum_Water_Content]	Single	4	(Internal) Optimum water content for the current soil as determined by the Quadratic fit
[Quadratic_Error]	Single	4	(Internal) R squared difference between experimental data and Quadratic equation
[Quadratic_Fit]	Boolean	1	(Internal) Has the Quadratic equation been fit to data?
[Woods_Curve]	Text	1	(Internal) Index of curve selected by Woods and Litehiser method (A to Z)
[Woods_Error]	Single	4	(Internal) R squared difference between experimental data and Woods and Litehiser estimation
[Woods_Estimated]	Boolean	1	(Internal) Has Woods and Litehiser estimation been performed?
[Woods_Maximum_Dry_Density]	Single	4	(Internal) Maximum Dry Density for the current soil as determined by the Woods estimation (kg/m^3)
[Woods_Optimum_Water_Content]	Single	4	(Internal) Optimum water content for the current soil as determined by the Woods estimation

Compression			
Name	FieldType	Length	Description
[aco]	Single	4	(Internal) Fit parameter
[Collapse_During_Swell]	Single	4	Percentage of soil structure collapse during swell phase of constant volume test
[Comp_ID]	GUID	16	(Internal) Counter
[Compression_Dry_Density]	Single	4	Dry density at the start of the oedometer compression test (kg/m^3)
[Compression_Error]	Single	4	(Internal) R squared difference between fit curve and experimental data
[Compression_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit (True/False)
[Compression_History]	Byte	1	Indicates if the soil is 1-Normally consolidated or 2-Overconsolidated
[Compression_Index]	Single	4	(Internal) Compression Index, Cc
[Compression_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Compression_Oedometer_Specimen_ID]	Text	15	ID for specimen used in test
[Compression_Soil_Counter]	Long	4	Link to main soil properties table

[Compression_Specimen_Diameter]	Single	4	Diameter of the soil specimen (mm)
[Compression_Specimen_Height]	Single	4	Height of the soil specimen (mm)
[Compression_Technician]	Text	50	Technician responsible for experimental results
[Compression_Test]	Byte	1	Describes the type of experimental test used to obtain compression curve
[Compression_Test_Date]	Date	8	Date lab test was performed
[Compression_Test_Method]	Text	100	Test method used to obtain experimental results
[Compression_Triaxial_Specimen_ID]	Text	15	ID for specimen used in test
[Compression_Water_Content_After]	Single	4	Gravimetric water content at the finish of the oedometer compression test (g/g)
[Compression_Water_Content_Before]	Single	4	Gravimetric water content at the start of the oedometer compression test (g/g)
[FHA_Initial_State]	Text	20	Initial state of the soil sample used in the FHA soil swell test
[FHA_Ring_Pressure]	Single	4	Proving ring pressure as recorded in the FHA soil swell test
[FHA_Swell]	Single	4	Percent swell as recorded in the FHA soil swell test
[hrco]	Single	4	(Internal) Fixed fitting parameter relating to lower part of curve
[Maximum_Stress]	Single	4	(Internal) Maximum stress that will yield a zero void ratio for the Two Slope equation (kPa)
[mco]	Single	4	(Internal) Fit parameter
[nco]	Single	4	(Internal) Fit parameter
[Oedometer_Compression_Count]	Integer	2	(Internal) Stores the number of experimentally measured points on the compression curve
[Oedometer_Rebound_Count]	Integer	2	(Internal) Stores the number of experimentally measured points on the rebound curve
[Overburden_Pressure]	Single	4	Overburden pressure exerted on specimen in the field (kPa)
[Percent_Collapse]	Single	4	Percentage of soil structure collapse when maximum load is applied in the oedometer compression test
[Poissons_Ratio]	Single	4	Constant relating stresses in different directions
[Preconsolidation_Pressure]	Single	4	(Internal) Preconsolidation pressure for the compression curve (kPa)
[Rebound_Error]	Single	4	(Internal) R squared difference between fit rebound curve and experimental data
[Rebound_Fit]	Boolean	1	(Internal) Indicates if experimental rebound data has been fit with an equation
[Rebound_Preconsolidation_Pressure]	Single	4	(Internal) Preconsolidation pressure for the rebound curve (kPa)
[Rebound_Swelling_Index]	Single	4	(Internal) Swelling index, Cs as determined from rebound experimental data
[Rebound_Swelling_Pressure]	Single	4	(Internal) Swelling pressure for the rebound curve (kPa)

[Rebound_Void_Ratio]	Single	4	(Internal) Void ratio at the start of the rebound curve
[Swelling_Index]	Single	4	(Internal) Swelling Index, Cs as determined from compression experimental data
[Swelling_Pressure]	Single	4	(Internal) Swelling pressure of the soil (kPa)
[Two_Slope_Error]	Single	4	(Internal) R squared difference between fit two slope curve and experimental data
[Two_Slope_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with the two slope equation
[Water_Added]	Single	4	Net normal stress at which water was added to the sample in the oedometer compression test (kPa)

Compression_Triaxial			
Name	FieldType	Length	Description
[Iso_Comp_Error]	Single	4	(Internal) R squared difference between fit two slope curve and triaxial experimental data
[Iso_Comp_Fit]	Boolean	1	(Internal) Indicates if triaxial compression experimental data has been fit with the two slope equation
[Iso_Comp_Kappa]	Single	4	(Internal) Slope of the recompression branch of the compression curve in the isotropic triaxial test
[Iso_Comp_Swelling_Pressure]	Single	4	(Internal) Swelling pressure of the soil in the isotropic triaxial test (kPa)
[Iso_Compression_Count]	Integer	2	(Internal) Stores the number of experimentally measured points on the compression curve
[Iso_Compression_History]	Byte	1	Indicates if the soil is 1-Normally consolidated or 2-Overconsolidated
[Iso_Compression_Test]	Byte	1	Describes the type of experimental test used to obtain compression curve
[Iso_Dry_Density]	Single	4	Dry density at the start of the oedometer compression test (kg/m^3)
[Iso_ID]	GUID	16	(Internal) Counter
[Iso_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Iso_Lambda]	Single	4	(Internal) Slope of virgin compression line in isotropic triaxial test
[Iso_Maximum_Stress]	Single	4	(Internal) Maximum stress that will yield a zero void ratio for the Two Slope equation fit of isotropic triaxial data (kPa)
[Iso_Overburden_Pressure]	Single	4	Overburden pressure exerted on specimen in the field (kPa)
[Iso_Poissons_Ratio]	Single	4	Constant relating stresses in different directions
[Iso_Preconsolidation_Pressure]	Single	4	(Internal) Preconsolidation pressure for the triaxial compression curve (kPa)
[Iso_Rebound_Count]	Integer	2	(Internal) Stores the number of experimentally measured points on the rebound curve
[Iso_Rebound_Error]	Single	4	(Internal) R squared difference between fit two slope curve and triaxial experimental

			rebound data
[Iso_Rebound_Fit]	Boolean	1	(Internal) Indicates if triaxial rebound experimental data has been fit with the two slope equation
[Iso_Rebound_Kappa]	Single	4	(Internal) Slope of the rebound branch of the swelling curve in the isotropic triaxial test
[Iso_Rebound_Preconsolidation_Pressure]	Single	4	(Internal) Preconsolidation pressure for the rebound curve in the triaxial compression curve (kPa)
[Iso_Rebound_Swelling_Pressure]	Single	4	(Internal) Swelling pressure of the rebound curve in the isotropic triaxial test (kPa)
[Iso_Rebound_Void_Ratio]	Single	4	(Internal) Void ratio at the start of the rebound curve in the isotropic triaxial test
[Iso_Soil_Counter]	Long	4	Link to main soil properties table
[Iso_Specimen_Diameter]	Single	4	Diameter of the soil specimen (mm)
[Iso_Specimen_Height]	Single	4	Height of the soil specimen (mm)
[Iso_Specimen_ID]	Text	15	ID for specimen used in test
[Iso_Technician]	Text	50	Technician responsible for experimental results
[Iso_Test_Date]	Date	8	Date lab test was performed
[Iso_Test_Method]	Text	100	Test method used to obtain experimental results
[Iso_Water_Content_After]	Single	4	Gravimetric water content at the finish of the oedometer compression test (g/g)
[Iso_Water_Content_Before]	Single	4	Gravimetric water content at the start of the oedometer compression test (g/g)

Diffusion			
Name	FieldType	Length	Description
[add]	Single	4	(Internal) Parameter controlling break point of frozen fit
[adw]	Single	4	(Internal) Parameter controlling break point of frozen fit
[Cf]	Single	4	Coefficient of film diffusion (m^2/s)
[Diffu_ID]	GUID	16	(Internal) Record counter
[Diffusion_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the diffusion curve
[Diffusion_Drying_Fit]	Boolean	1	(Internal) Has diffusion curve been fit?
[Diffusion_Drying_Fit_Error]	Single	4	(Internal) R squared difference between experimental or predicted and fit data
[Diffusion_Drying_Source]	Byte	1	(Internal) Indicates if the equation should be fit to experimental (0) or predicted (1) data
[Diffusion_Error]	Single	4	(Internal) R squared difference between experimental and predicted data
[Diffusion_Fit_Type]	Byte	1	Type of fit of soil-water characteristic curve to use in prediction
[Diffusion_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Diffusion_Parameter]	Single	4	Coefficient used to vary prediction

[Diffusion_Predicted]	Boolean	1	(Internal) Indicates if prediction needs to be performed (True/False)
[Diffusion_Soil_Counter]	Long	4	Link to main soil properties table
[Diffusion_Specimen_ID]	Text	15	ID of specimen used in test
[Diffusion_Technician]	Text	50	Technician responsible for experimental results
[Diffusion_Test]	Boolean	1	Indicates if parameters were determined experimentally (True) or estimated (False)
[Diffusion_Test_Date]	Date	8	Date lab test was performed
[Diffusion_Test_Method]	Text	100	Test method used to obtain experimental results
[Diffusion_Wetting_Fit]	Boolean	1	(Internal) Has diffusion curve been fit?
[Diffusion_Wetting_Fit_Error]	Single	4	(Internal) R squared difference between experimental or predicted and fit data
[Ds]	Single	4	Coefficient of diffusion for saturated soil (m^2/s)
[mdd]	Single	4	(Internal) Parameter controlling curvature of the fit curve
[mdw]	Single	4	(Internal) Parameter controlling curvature of the fit curve
[ndd]	Single	4	(Internal) Parameter controlling steepest slope of fit curve
[ndw]	Single	4	(Internal) Parameter controlling steepest slope of fit curve

Geochemistry			
Name	FieldType	Length	Description
[Geochemistry_ID]	GUID	16	
[Geochemistry_Soil_Counter]	Long	4	Link to the main soils table
[Geochem_Specimen_ID]	Text	15	ID of soil specimen
[CEC]	Single	4	Cation exchange capacity (meq/100g)
[pH]	Single	4	pH of soil (0-14)
[Electrolyte_Level]	Single	4	Electrolyte Level (meq/l)
[SAR]	Single	4	Sodium adsorption ratio (meq/l)
[Free_Fe_and_Al_Oxide]	Single	4	Free iron and aluminum oxide (%)
[Water_Chemistry_Count]	Integer	2	Number of records entered to describe the water and soil chemistry

Grainsize			
Name	FieldType	Length	Description
[abi]	Single	4	(Internal) Bimodal curve fitted parameter
[agr]	Single	4	(Internal) Calculated 'a' parameter
[Alpha]	Single	4	Correction factor for specific gravity in hydrometer test
[Bimodal_Error]	Single	4	(Internal) R squared difference between fit Bimodal curve and experimental data
[Bimodal_Fit]	Boolean	1	(Internal) Indicates if bimodal curve has been fit to experimental data (True/False)

[Bimodal_Split]	Single	4	(Internal) Indicates split between upper and lower bimodal equations (between 0.0 and 1.0)
[D10]	Single	4	Diameter relating to 10% passing
[D20]	Single	4	Diameter relating to 20% passing
[D30]	Single	4	Diameter relating to 30% passing
[D50]	Single	4	Diameter relating to 50% passing
[D60]	Double	8	Diameter relating to 60% passing
[Dispersing_Agent]	Text	50	Name of agent used to diperse particles in hydrometer test
[Dispersing_Agent_Amount]	Text	50	Amount of agent used in hydrometer test
[Double_Hydrometer]	Text	10	Results of the Double Hydrometer Test
[Effective_Grain_Diameter]	Single	4	(Internal) Dominant or effective particle size diameter according to the Zamarin equation (mm)
[Grain_ID]	GUID	16	(Internal) Record counter
[Grainsize_Hydrometer_Specimen_ID]	Text	15	ID of specimen used in hydrometer test
[Grainsize_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Grainsize_Sieve_Specimen_ID]	Text	15	ID of specimen used in test
[Grainsize_Soil_Counter]	Long	4	Link to main soil properties table
[Grainsize_Technician]	Text	50	Technician responsible for experimental results
[Grainsize_Test_Date]	Date	8	Date lab test was performed
[Grainsize_Test_Method]	Text	100	Test method used to obtain experimental results
[Graphic_Mean]	Single	4	Graphic measure of overall size
[Graphic_Skewness]	Single	4	A measure of skewness (68% of curve)
[Graphic_Standard_Deviation]	Single	4	Standard mean 68% of the curve)
[HMP_Concentration]	Double	8	HMP solution concentration (g/cm^3)
[hrbi]	Single	4	(Internal) Fixed parameter which indicates residual portion of bimodal curve
[hrgr]	Single	4	(Internal) Fixed parameter which indicates residual portion of curve
[Hydrometer_Count]	Byte	1	(Internal) Stores the number of points on the grain-size distribution curve measured with the hydrometer analysis
[Hydrometer_No]	Text	50	Name of Hydrometer used in hydrometer test
[Hydrometer_Percentage]	Single	4	Percentage of the total soil sample (by weight) used in hydrometer test
[Hydrometer_Sample]	Single	4	Weight soil used in hyrometer test (g) in hydrometer test
[Inclusive_Graphic_Skewness]	Single	4	A measure of skewness (90% of curve)
[Inclusive_Graphic_Standard_Deviation]	Single	4	Standard mean (90% of the curve)
[jbi]	Single	4	(Internal) Bimodal curve fitted parameter
[kbi]	Single	4	(Internal) Bimodal curve fitted parameter
[Kurtosis]	Single	4	Measure of departure from normality

[lbi]	Single	4	(Internal) Bimodal curve fitted parameter
[Maximum_Sampler_Size]	Text	50	Maximum Sampler Size
[mbi]	Single	4	(Internal) Bimodal curve fitted parameter
[Median]	Single	4	Diameter at 50% passing (same as D50)
[Meniscus_Correction]	Single	4	Correction factor used for the meniscus in hydrometer test
[mgr]	Single	4	(Internal) Calculated 'm' parameter
[Mode]	Single	4	Most frequently occuring diameter (mm)
[nbi]	Single	4	(Internal) Bimodal curve fitted parameter
[ngr]	Single	4	(Internal) Calculated 'n' parameter
[Percent_Organic]	Single	4	Percent organic
[Phi_Quartile_Skewness]	Single	4	Shows where the excess amount in the sediment is
[PinHole_Method]	Text	6	Results of the PinHole Method Test
[Sieve_Container]	Single	4	Weight of container (g)
[Sieve_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the grainsize curve
[Sieve_Sample]	Single	4	Weight of dry sample (g)
[Sieve_Sample_and_Container]	Single	4	Weight of dry sample plus container (g)
[Smallest_Particle_Size]	Single	4	Smallest particle size in current soil (mm)
[Standard_Used]	Single	4	The hydrometer calculation method used
[Unimodal_Error]	Single	4	(Internal) R squared difference between fit Fredlund curve and experimental data
[Unimodal_Fit]	Boolean	1	(Internal) Indicates if Fredlund curve has been fit to experimental data (True/False)
[USCS_Percent_Clay]	Single	4	USCS Percent Clay
[USCS_Percent_Coarse]	Single	4	Percent coarse
[USCS_Percent_Sand]	Single	4	USCS Percent Sand
[USCS_Percent_Silt]	Single	4	USCS Percent Silt
[USDA_Percent_Clay]	Single	4	USDA Percent Clay
[USDA_Percent_Coarse]	Single	4	USDA Percent Coarse
[USDA_Percent_Sand]	Single	4	USDA Percent Sand
[USDA_Percent_Silt]	Single	4	USDA Percent Silt
[Zero_Correction]	Single	4	Correction factor used in water temperature change in hydrometer test

kVoid			
Name	FieldType	Length	Description
[kVoid_Count]	Byte	1	(Internal) Number of experimental points on the coefficient of permeability vs. void ratio curve
[kVoid_ID]	GUID	16	(Internal)
[kVoid_Lab_Notes]	Memo	0	Notes by laboratory technician on test

[kVoid_Soil_Counter]	Long	4	Link to the main table
[kVoid_Specimen_ID]	Text	15	ID of specimen used in test
[kVoid_Technician]	Text	50	Technician responsible for experimental results
[kVoid_Test_Date]	Date	8	Date lab test was performed
[kVoid_Test_Method]	Text	150	Test method used to obtain experimental results
[Taylor_Coefficient]	Single	4	Coefficient used by Taylor to estimate hydraulic conductivity at various void ratios
[Taylor_Error]	Single	4	(Internal) R squared difference between experimental and Taylor predicted results
[Taylor_Predicted]	Boolean	1	(Internal) Has Taylor's prediction been executed?

Lab_AtterbergLimits			
Name	FieldType	Length	Description
[AL_ID]	GUID	16	(Internal)
[AL_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[AL_Soil_Counter]	Long	4	Link to the main table
[AL_Specimen_ID]	Text	15	ID of specimen used in test
[AL_Technician]	Text	50	Technician responsible for experimental results
[AL_Test_Date]	Date	8	Date lab test was performed
[AL_Test_Method]	Text	150	Test method used to obtain experimental results

Lab_SpecificGravity			
Name	FieldType	Length	Description
[SG_ID]	GUID	16	(Internal)
[SG_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[SG_Soil_Counter]	Long	4	Link to the main table
[SG_Specimen_ID]	Text	15	ID of specimen used in test
[SG_Technician]	Text	50	Technician responsible for experimental results
[SG_Test_Date]	Date	8	Date lab test was performed
[SG_Test_Method]	Text	150	Test method used to obtain experimental results

Lab_WaterContent			
Name	FieldType	Length	Description
[WC_ID]	GUID	16	(Internal)
[WC_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[WC_Soil_Counter]	Long	4	Link to the main table
[WC_Specimen_ID]	Text	15	ID of specimen used in test
[WC_Technician]	Text	50	Technician responsible for experimental results

[WC_Test_Date]	Date	8	Date lab test was performed
[WC_Test_Method]	Text	150	Test method used to obtain experimental results

Mineralogy			
Name	FieldType	Length	Description
[Mineral]	Text	50	Mineral in soil makeup
[Mineral_ID]	GUID	16	(Internal) Record counter
[Mineralogy_Soil_Counter]	Long	4	Link to main soil properties table
[Percentage_of_Mineral]	Single	4	Percentage of mineral in soil

Permeability			
Name	FieldType	Length	Description
[aga]	Single	4	(Internal) Fitting parameter for Gardner fit of the hydraulic conductivity function
[Campbell_Error]	Single	4	(Internal) R squared difference between experimental and predicted data
[Campbell_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[Campbell_p]	Single	4	Parameter used to vary Campbell conductivity prediction
[Campbell_Predicted]	Boolean	1	(Internal) Indicates if prediction has been executed (True/False)
[Corey_Error]	Single	4	(Internal) R squared difference between drying experimental and Brooks and Corey predicted data
[Corey_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[Corey_Predicted]	Boolean	1	(Internal) Indicates if prediction has been executed (True/False)
[Dry_Air_ksat]	Single	4	Experimentally measured dry soil air hydraulic conductivity (m/s)
[Field_Permeability_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the field conductivity curve
[Fredlund_Drying_Error]	Single	4	(Internal) R squared difference between drying experimental and drying predicted data
[Fredlund_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[Fredlund_Predicted]	Boolean	1	(Internal) Indicates if prediction has been executed (True/False)
[Gardner_Fit]	Boolean	1	(Internal) Indicates if fit has been executed (True/False)
[Gardner_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[Gardner_Permeability_Error]	Single	4	(Internal) R squared difference between drying experimental and Gardner fit data
[Kunze_Error]	Single	4	(Internal) R squared difference between drying experimental and Kunze fit data

[Kunze_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[Kunze_Predicted]	Boolean	1	(Internal) Indicates if estimation has been executed (True/False)
[Kxy_ID]	GUID	16	(Internal) Record counter
[Lab_Permeability_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the laboratory conductivity curve
[Leong_Error]	Single	4	(Internal) R squared difference between drying experimental and Leong estimated data
[Leong_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[Leong_p]	Single	4	Variable used in the calculation of the permeability function
[Leong_Predicted]	Boolean	1	(Internal) Indicates if estimation has been executed (True/False)
[MCampbell_Error]	Single	4	(Internal) R squared difference between experimental and predicted data
[MCampbell_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the modified Campbell estimation
[MCampbell_p]	Single	4	Parameter used to vary the modified Campbell conductivity prediction
[MCampbell_Predicted]	Boolean	1	(Internal) Indicates if prediction has been executed (True/False)
[Mualem_Error]	Single	4	(Internal) R squared difference between drying experimental and Mualem estimated data
[Mualem_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[Mualem_Predicted]	Boolean	1	(Internal) Indicates if estimation has been executed (True/False)
[nga]	Single	4	(Internal) Fitting parameter for Gardner fit of the hydraulic conductivity function
[Permeability_Drying_Specimen_ID]	Text	15	ID of specimen used in drying test
[Permeability_Field_Specimen_ID]	Text	15	ID of specimen used in field drying test
[Permeability_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Permeability_Soil_Counter]	Long	4	Link to main soil properties table
[Permeability_Specimen_Diameter]	Single	4	Diameter of specimen used in permeability test (mm)
[Permeability_Specimen_Length]	Single	4	Length of specimen used in permeability test (mm)
[Permeability_Technician]	Text	50	Technician responsible for experimental results
[Permeability_Test_Date]	Date	8	Date lab test was performed
[Permeability_Test_Method]	Text	255	Test method used to obtain experimental results
[van_Genuchten_Error]	Single	4	(Internal) R squared difference between drying experimental and van Genuchten predicted data

[van_Genuchten_Linked_ksat]	Byte	1	Saturated hydraulic conductivity which is used as a starting point for the estimation
[van_Genuchten_Predicted]	Boolean	1	(Internal) Indicates if prediction has been executed (True/False)

Permeability_k			
Name	FieldType	Length	Description
[Air_Entry_ksat]	Single	4	Saturated hydraulic conductivity from experimental points at suctions less than air entry (m/s)
[Beyer_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Beyer equation (m/s)
[FairHatch_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Fair-Hatch equation (m/s)
[FairHatch_SandShapeFactor]	Single	4	Sand Shape Factor used by Fair-Hatch equation in the estimation of saturated hydraulic conductivity
[Field_ksat]	Single	4	Saturated hydraulic conductivity measured in the field (m/s)
[Hazens_Constant]	Single	4	Constant used by Hazen's equation in the estimation of saturated hydraulic conductivity
[Hazens_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by Hazen's equation (m/s)
[Inverse_ksat]	Single	4	Saturated hydraulic conductivity back-calculated from experimental curve using Fredlund and Xing permeability estimation (m/s)
[Kozeny_Carman_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Kozeny-Carman equation (m/s)
[Kozeny_Constant]	Single	4	Constant used by Kozeny-Carman equation in the estimation of saturated hydraulic conductivity
[Kozeny_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Kozeny equation (m/s)
[Kruger_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Kruger equation (m/s)
[ksat_ID]	GUID	16	(Internal) Record counter
[ksat_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[ksat_Soil_Counter]	Long	4	Link to main soil properties table
[ksat_Specimen_Diameter]	Single	4	Diameter of specimen used in permeability test (mm)
[ksat_Specimen_ID]	Text	15	ID of specimen used in ksat test
[ksat_Specimen_Length]	Single	4	Length of specimen used in permeability test (mm)
[ksat_Technician]	Text	50	Technician responsible for experimental results
[ksat_Test_Date]	Date	8	Date lab test was performed
[ksat_Test_Method]	Text	255	Test method used to obtain experimental results
[Laboratory_ksat]	Single	4	Saturated hydraulic conductivity measured

			in the laboratory (m/s)
[Perm_Stress_State]	Single	4	Stress State (kPa)
[Rawls_1983_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Rawls 1983 equation (m/s)
[Rawls_1993_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Rawls 1993 equation (m/s)
[Slichter_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Slichter equation (m/s)
[Terzaghi_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Terzaghi equation (m/s)
[USBR_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the USBR equation (m/s)
[Zamarin_ksat]	Single	4	(Internal) Saturated hydraulic conductivity as estimated by the Zamarin equation (m/s)

ShearBox			
Name	FieldType	Length	Description
[Direct_Shear_Area]	Single	4	Area of the shear plane in the direct shear test (mm^2)
[Direct_Shear_Specimen_Height]	Single	4	Height of the sample used in the direct shear test (mm)
[Residual_Shear]	Single	4	the Residual Shear (kPa)
[Shear_Box_Count]	Byte	1	(Internal) Stroes the number of experimentally measured points on the saturated shear strength curve
[Shear_Dry_Density]	Single	4	Dry density at the start of the shear box test (kg/m^3)
[Shear_Effective_Angle]	Single	4	Saturated effective angle of internal friction of soil as determined from the shear box test (degrees)
[Shear_Effective_Cohesion]	Single	4	Saturated effective cohesion of soil as determined from the shear box test (kPa)
[Shear_Error]	Single	4	(Internal) R squared difference between direct shear experimental data and saturated Mohr-Coulomb shear envelope
[Shear_ID]	GUID	16	(Internal) Record ounter
[Shear_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Shear_Parameter]	Single	4	Parameter used to determine the amount of influence the soil-water characteristic curve has on shear strength
[Shear_Predicted]	Boolean	1	(Internal) Indicates if prediction needs to be executed (True/False)
[Shear_Soil_Counter]	Long	4	Link to main soil properties table
[Shear_Technician]	Text	50	Technician responsible for experimental results
[Shear_Test_Date]	Date	8	Date shear box lab test was performed
[Shear_Test_Method]	Text	100	Test method used to obtain experimental results
[Shear_Unsat_Error]	Single	4	(Internal) R squared difference between experimental and unsaturated Mohr-Coulomb shear box envelope

[Shear_Water_Content_After]	Single	4	Gravimetric water content at the end of the shear box test (g/g)
[Shear_Water_Content_Before]	Single	4	Gravimetric water content at the start of the shear box test (g/g)
[Ultimate_Shear]	Single	4	The Ultimate Shear (kPa)

ShearTriaxial			
Name	FieldType	Length	Description
[Shear_Parameter]	Single	4	Parameter used to determine the amount of influence the soil-water characteristic curve has on shear strength
[Traixial_Dry_Density]	Single	4	Dry density at the start of the triaxial shear test (kg/m^3)
[Triaxial_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the shear strength curve
[Triaxial_Effective_Angle]	Single	4	Saturated effective angle of internal friction of soil as determined from the triaxial test (degrees)
[Triaxial_Effective_Cohesion]	Single	4	Saturated effective cohesion of soil as determined from the triaxial test (kPa)
[Triaxial_Error]	Single	4	(Internal) R squared difference between triaxial experimental data and saturated Mohr-Coulomb shear envelope
[Triaxial_Failure_Mode]	Text	50	Mode of failure of the triaxial test
[Triaxial_ID]	GUID	16	(Internal) Record ounter
[Triaxial_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Triaxial_Soil_Counter]	Long	4	Link to main soil properties table
[Triaxial_Specimen_Diameter]	Single	4	Diameter of specimen used in triaxial test (mm)
[Triaxial_Specimen_Height]	Single	4	Height of specimen used in triaxial test (mm)
[Triaxial_Technician]	Text	50	Technician responsible for experimental results
[Triaxial_Test_Date]	Date	8	Date triaxial lab test was performed
[Triaxial_Test_Method]	Text	100	Test method used to obtain experimental results
[Triaxial_Unsat_Error]	Single	4	(Internal) R squared difference between experimental and unsaturated Mohr-Coulomb triaxial envelope
[Triaxial_Water_Content_After]	Single	4	Gravimetric water content at the start of the triaxial shear test (g/g)
[Triaxial_Water_Content_Before]	Single	4	Gravimetric water content at the start of the triaxial shear test (g/g)

Shrinkage			
Name	FieldType	Length	Description
[ash]	Single	4	(Internal) Shrinkage curve-fit parameter
[bsh]	Single	4	(Internal) Shrinkage curve-fit parameter
[csh]	Single	4	(Internal) Shrinkage curve-fit parameter
[Estimated_Air_Entry_Value]	Single	4	(Internal) Estimated air entry value of a soil represented as soil suction (kPa)

[Estimated_ash]	Single	4	Estimated minimum void ratio
[Estimated_bsh]	Single	4	(Internal) Estimated parameter based on specific gravity of soil
[Estimated_csh]	Single	4	Estimated curvature of shrinkage curve
[Estimated_Shrinkage_Limit]	Single	4	(Internal) Gravimetric water content corresponding to minimum void ratio possible with estimated shrinkage curve
[Shrink_ID]	GUID	16	(Internal) Counter
[Shrinkage_Count]	Integer	2	(Internal) Number of experimentally measured data points on the shrinkage curve
[Shrinkage_Estimated]	Boolean	1	(Internal) Has shrinkage curve been estimated? (Yes=True, No=False)
[Shrinkage_Estimated_Error]	Single	4	(Internal) R squared difference between estimation and experimental data
[Shrinkage_Fit]	Boolean	1	(Internal) Has shrinkage equation been fit to data?
[Shrinkage_Fit_Error]	Single	4	(Internal) R squared difference between equation and data points
[Shrinkage_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Shrinkage_Limit]	Single	4	(Internal) Gravimetric water content corresponding to minimum void ratio possible with fit shrinkage of soil
[Shrinkage_Soil_Counter]	Long	4	Link to main soil properties table
[Shrinkage_Specimen_ID]	Text	15	ID of specimen used in test
[Shrinkage_Technician]	Text	50	Technician responsible for experimental results
[Shrinkage_Test_Date]	Date	8	Date lab test was performed
[Shrinkage_Test_Method]	Text	100	Test method used to obtain experimental results
[True_Air_Entry_Value]	Single	4	(Internal) True air entry value of a soil represented as soil suction (kPa)

Soils			
Name	FieldType	Length	Description
[Activity]	Single	4	Activity of a soil as determined from the clay content
[Atterberg_Present]	Boolean	1	(Internal) Is atterberg limits information present for the current soil?
[Author]	Text	150	Author of paper in which soil was published
[COLE]	Single	4	Coefficient of linear extensibility
[Compaction_Present]	Boolean	1	(Internal) Is compaction information present for the current soil?
[Compression_Oedometer_Present]	Boolean	1	(Internal) Is oedometer consolidation information present for current soil?
[Compression_Triaxial_Present]	Boolean	1	(Internal) Is triaxial compression information present for current soil?
[Cone_rate]	Single	4	Rate of penetration of a cone being pushed into the soil
[Consistency]	Text	50	Relative stiffness of a soil
[Contact]	Text	180	Individual that contributed soil to database

[Country]	Text	80	Country where soil is located
[Date_Entered]	Date	8	(Internal) Date the soil information was entered into the database
[Date_Sampled]	Date	8	Year soil was sampled
[Depth_to_Groundwater]	Single	4	Depth to groundwater table (m)
[Diffusion_Present]	Boolean	1	(Internal) Is diffusion information present for current soil?
[Dip]	Single	4	Angle of a soil or rock fracture from the horizontal (degrees)
[Drainage]	Text	35	Drainage pattern where soil sample was obtained
[Dry_Density]	Single	4	Dry density
[Experimentally_Determined]	Boolean	1	Indicates if properties have been experimentally determined (True/False)
[Family]	Text	150	Family of current soil
[Field_1]	Text	255	Extra field
[Field_2]	Text	255	Extra field
[Field_3]	Text	255	Extra field
[Field_4]	Text	255	Extra field
[Field_5]	Text	255	Extra field
[Figure_Title]	Text	150	Title of the figure in the paper in which the data was published
[Filter_Paper_Dry]	Single	4	Weight of the dry Filter paper
[Filter_Paper_Suction]	Single	4	Suction of Filter paper
[Filter_Paper_Type]	Text	50	Type of Filter Paper used
[Filter_Paper_WaterContent]	Single	4	Water Content of Filter paper
[Filter_Paper_Wet]	Single	4	Weight of the wet Filter paper
[Geochemistry_Present]	Boolean	1	(Internal) Is geochemistry information present for the current soil?
[Geologic_Description]	Text	255	Geological description of the current soil
[Grainsize_Present]	Boolean	1	(Internal) Is grainsize information present?
[Horizon_Code]	Text	15	Code for current horizon
[Horizon_Depth_Lower]	Single	4	Lower depth of sampling (m)
[Horizon_Depth_Upper]	Single	4	Upper depth of sampling (m)
[Horizon_Number]	Integer	2	Horizon number where soil was obtained
[HVEEM_Displacement]	Single	4	Displacement recorded for the HVEEM-CARMANY test (mm)
[HVEEM_Expansion]	Single	4	Expansion recorded for the HVEEM-CARMANY test (mm)
[HVEEM_Pressure]	Single	4	Exudation pressure used to determin the R-value for the HVEEM-CARMANY test (kPa)
[HVEEM_RValue]	Single	4	R-value for the HVEEM-CARMANY test
[Initial_State]	Text	10	Indicates the initial stress state of the current soil
[Journal_Name]	Text	150	Name of journal paper was published in
[ksat_Present]	Boolean	1	(Internal) Is saturated permeability information present for current soil?

[kVoid_Present]	Boolean	1	(Internal) Is permeability vs. void ratio information present for the current soil?
[Land_Use]	Text	30	Land use where soil sample was obtained
[Length_pushed]	Single	4	Length of sample pushed in tube (m)
[Length_recovered]	Single	4	Length of sample tube successfully recovered (m)
[Liquid_Limit]	Single	4	Liquid limit
[Locked_DD]	Boolean	1	(Internal) Indicates if dry density is locked (True/False)
[Locked_S]	Boolean	1	(Internal) Indicates if saturation is locked (True/False)
[Locked_SG]	Boolean	1	(Internal) Indicates if specific gravity is locked (True/False)
[Locked_TD]	Boolean	1	(Internal) Indicates if total density is locked (True/False)
[Locked_VR]	Boolean	1	(Internal) Indicates if void ratio is locked (True/False)
[Locked_VWC]	Boolean	1	(Internal) Indicates if volumetric water content is locked (True/False)
[Locked_WC]	Boolean	1	(Internal) Indicates if gravimetric water content is locked (True/False)
[Mineralogy_Count]	Integer	2	Number of records entered to describe the mineralogy of the soil
[Munsell_Chroma]	Byte	1	Munsell color system chroma
[Munsell_Hue]	Text	10	Munsell color system hue
[Munsell_Value]	Byte	1	Munsell color system value
[N]	Single	4	Standard penetration test results (blows/m)
[Notes]	Memo	0	Notes about the current soil
[Number_of_Horizons]	Integer	2	Total number of soil horizons
[Original_Index]	Text	20	Index from the original dataset from which the soil was imported
[Page_Numbers]	Text	30	Page numbers of journal
[Paper_Name]	Text	150	Paper name where soil was published
[Permeability_Present]	Boolean	1	(Internal) Is unsaturated permeability information present for current soil?
[Plastic_Limit]	Single	4	Plastic limit
[Plasticity_Index]	Single	4	Liquid Limit - Plastic Limit
[Pocket_penetrometer]	Single	4	Measure of the compressive strength of a soil (kPa)
[Porosity]	Single	4	Porosity
[Province]	Text	80	Province where soil is located
[Publisher]	Text	100	Publisher of paper
[Push_pressure]	Single	4	Pressure exerted on sampling tube to obtain sample (kPa)
[Region]	Text	80	Region where soil is located
[Rock_quality]	Text	50	Qualitative description of the quality of the rock retrieved during a coring operation
[RPM]	Single	4	Revolutions per minute of the drill stem (rev/min)

[Sample_Depth_Lower]	Single	4	Depth to location of bottom of soil sample (m)
[Sample_Depth_Upper]	Single	4	Depth to location of top of soil sample (m)
[Sample_ID]	Text	10	A character string used to uniquely identify the soil sample
[Saturation]	Single	4	Saturation
[Sensitivity]	Single	4	Sensitivity of the soil
[Shear_Box_Present]	Boolean	1	(Internal) Is shear box information present for current soil?
[Shear_Triaxial_Present]	Boolean	1	(Internal) Is triaxial shear information present for current soil?
[Shrinkage_Present]	Boolean	1	(Internal) Is shrinkage information present for the current soil?
[ShrinkageLimit_Present]	Boolean	1	(Internal) Is shrinkage limit information present for the current soil?
[Site]	Text	150	Site where soil is located
[Slope]	Single	4	Slope where soil sample was obtained (L/L)
[Soil_Borehole_ID]	Text	10	Borehole of soil. Soils are typically grouped together if from the same borehole.
[Soil_Counter]	Long	4	(Internal) Primary soil record index
[Soil_Dataset_ID]	Text	20	Link to Dataset table
[Soil_Description]	Text	200	A description of the current soil
[Soil_Name]	Text	150	Name of soil
[Soil_Picture]	OLE Object	0	Picture of current soil
[Soil_Project_ID]	Text	20	Link to the Project table
[Soil_Series]	Text	50	Series of soil
[Specific_Gravity]	Single	4	Specific gravity
[Specific_Heat_Present]	Boolean	1	(Internal) Is specific heat information present for current soil?
[Specific_Surface]	Single	4	Amount of surface area per unit weight of the soil (m^2/g)
[SpecificGravity_Present]	Boolean	1	(Internal) Is specific gravity information present for the current soil?
[Specimen_ID]	Text	20	Identification of specimen used for volume-mass lab procedures
[Strike]	Single	4	Direction of maximum slope of a soil or rock fracture from North (degrees)
[Structure_Grade]	Text	20	Structure grade of soil
[Structure_Size]	Text	25	Structure size of soil
[Structure_Type]	Text	18	Structure type of soil
[SWCC_Drying_Present]	Boolean	1	(Internal) Is drying SWCC information present for current soil?
[SWCC_Wetting_Present]	Boolean	1	(Internal) Is wetting SWCC information present for current soil?
[Texture_Modifier]	Text	20	Texture modifier of soil
[Thermal_Present]	Boolean	1	(Internal) Is thermal conductivity information present for current soil?
[Torvane_shear_stress]	Single	4	The shear strength of a soil measured using a Torvane device (kPa)

[Total_Density]	Single	4	Total density (kg/m^3)
[Total_Unit_Weight]	Single	4	Total unit weight (kN/m^3)
[Unfrozen_Present]	Boolean	1	(Internal) Is frozen SWCC information present for current soil?
[USCS_Texture]	Text	40	Texture of soil according to the USCS classification system
[USDA_Texture]	Text	40	Texture of soil according to the USDA classification system
[Version_Entered]	Single	4	SoilVision version number which was used to enter or import data
[Void_Ratio]	Single	4	Void ratio
[Volume]	Text	30	Volume number of journal
[Volume_Mass_Completed]	Boolean	1	(Internal) Have complete volume-mass properties been calculated?
[Volumetric_Water_Content]	Single	4	Volumetric water content
[Water_Chemistry_Count]	Integer	2	Number of records entered to describe the water chemistry of the soil
[Water_Content]	Single	4	Gravimetric water content
[WaterContent_Present]	Boolean	1	(Internal) Is water content information present for the current soil?
[Year_Published]	Integer	2	Year paper was published

Specific_Heat			
Name	FieldType	Length	Description
[SH_of_Soil]	Single	4	Specific heat of soil particles (J/kg.C)
[SpecHeat_ID]	GUID	16	(Internal) Record counter
[Specific_Fit_Type]	Byte	1	Type of fit of soil-water characteristic curve to use in prediction
[Specific_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Specific_Predicted]	Boolean	1	(Internal) Indicates if prediction has been executed (True/False)
[Specific_Soil_Counter]	Long	4	Link to main soil properties table
[Specific_Technician]	Text	50	Technician responsible for experimental results
[Specific_Test]	Boolean	1	Indicates if parameters where determined experimentally (True) or estimated (False)
[Specific_Test_Method]	Text	100	Test method used to obtain experimental results

SWCC_Drying			
Name	FieldType	Length	Description
[ab]	Single	4	(Internal) Variable parameter in Burdine equation
[ac]	Single	4	(Internal) Variable parameter in Brooks & Corey equation
[af]	Single	4	(Internal) Variable parameter in Fredlund & Xing equation
[afb]	Single	4	(Internal) Variable parameter in Fredlund Bimodal equation

[ag]	Single	4	(Internal) Variable parameter in Gardner equation
[am]	Single	4	(Internal) Variable parameter in Mualem equation
[Arya_AEV]	Single	4	(Internal) Air entry value calculated from the Arya pedo-transfer function (kPa)
[Arya_Alpha]	Single	4	Empirical constant used to vary the Arya and Paris prediction of water retention
[Arya_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Arya and Paris method
[Arya_Max_Slope]	Single	4	(Internal) Maximum slope of the Arya and Paris pedo-transfer function (unitless)
[Arya_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Arya and Paris method (True/False)
[avg]	Single	4	(Internal) Variable parameter in van Genuchten equation
[Aubertin_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Aubertin method (True/False)
[Aubertin_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Aubertin method
[Aubertin_AEV]	Single	4	(Internal) Air entry value calculated from the Aubertin pseudo-transfer function (kPa)
[Aubertin_Max_Slope]	Single	4	(Internal) Maximum slope of the Aubertin pedo-transfer function (unitless)
[Aubertin_Method]	Byte	1	Indicates if the Aubertin method should treat the soil as a granular or plastic material
[Brooks_AEV]	Single	4	(Internal) Air entry value calculated from the Brooks and Corey fit of the soil-water characteristic curve (kPa)
[Brooks_Error]	Single	4	(Internal) Sum of squared differences between Brooks & Corey fit and experimental or predicted data
[Brooks_Max_Slope]	Single	4	(Internal) Maximum slope of the Brooks and Corey fit of the soil-water characteristic curve (unitless)
[Brooks_Residual_WC]	Single	4	(Internal) Calculated residual volumetric water content from the Brooks & Corey equation
[Brooks_Source]	Byte	1	Indicates if the Brooks and Corey equation should be fit to experimental or predicted data
[Brooks_SWCC_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with Brooks & Corey equation
[Burdine_AEV]	Single	4	(Internal) Air entry value calculated from the Burdine fit of the soil-water characteristic curve (kPa)
[Burdine_Error]	Single	4	(Internal) Sum of squared differences between Burdine fit and experimental or predicted data
[Burdine_Max_Slope]	Single	4	(Internal) Maximum slope of the Burdine fit of the soil-water characteristic curve (unitless)

[Burdine_Residual_WC]	Single	4	(Internal) Calculated residual volumetric water content from the Burdine equation
[Burdine_SWCC_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with Burdine equation
[Fredlund_AEV]	Single	4	(Internal) Suction at which air begins to enter a soil and fill large pores as calculated from the Fredlund and Xing fit of the soil-water characteristic curve (kPa)
[Fredlund_Bimodal_Error]	Single	4	(Internal) Sum of squared differences between the experimental data and the Fredlund Bimodal fit
[Fredlund_Bimodal_Fit]	Boolean	1	(Internal) Indicates if the experimental data has been fit with the Fredlund Bimodal equation
[Fredlund_Bimodal_Source]	Byte	1	Source of data used for the bimodal fit (0=experimental, 1=predicted)
[Fredlund_Bimodal_Split]	Single	4	(Internal) Fraction to attribute to the first curve
[Fredlund_Error]	Single	4	(Internal) Sum of squared differences between the experimental and Fredlund & Xing fit curves
[Fredlund_Max_Slope]	Single	4	(Internal) Maximum slope of the Fredlund and Xing fit of the soil-water characteristic curve (unitless)
[Fredlund_PTF_AEV]	Single	4	(Internal) Air entry value calculated from the Fredlund pedo-transfer function (kPa)
[Fredlund_PTF_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Fredlund and Wilson method
[Fredlund_PTF_Max_Slope]	Single	4	(Internal) Maximum slope of the Fredlund and Wilson pedo-transfer function (unitless)
[Fredlund_PTF_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Fredlund and Wilson method (True/False)
[Fredlund_PTF_Source]	Byte	1	Indicates if the Fredlund & Xing equation should use the unimodal or bimodal grain-size curve as it's source
[Fredlund_Residual_WC]	Single	4	(Internal) Calculated residual volumetric water content from the Fredlund & Xing fit
[Fredlund_Source]	Byte	1	Indicates if the Fredlund & Xing equation should be fit to experimental or predicted data
[Fredlund_SWCC_Fit]	Boolean	1	(Internal) Indicates if the experimental data needs to be fit with the Fredlund & Xing equation (True/False)
[Gardner_AEV]	Single	4	(Internal) Air entry value calculated from the Gardner fit of the soil-water characteristic curve (kPa)
[Gardner_Error]	Single	4	(Internal) Sum of squared differences between Gardner fit and experimental or predicted data
[Gardner_Max_Slope]	Single	4	(Internal) Maximum slope of the Gardner fit of the soil-water characteristic curve (unitless)
[Gardner_Residual_WC]	Single	4	(Internal) Calculated residual volumetric water content from the Gardner equation

[Gardner_SWCC_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with Gardner equation
[Genuchten_AEV]	Single	4	(Internal) Air entry value calculated from the van Genuchten fit of the soil-water characteristic curve (kPa)
[Genuchten_Error]	Single	4	(Internal) Sum of squared differences between van Genuchten fit and experimental or predicted data
[Genuchten_Max_Slope]	Single	4	(Internal) Maximum slope of the van Genuchten fit of the soil-water characteristic curve (unitless)
[Genuchten_Residual_WC]	Double	8	(Internal) Calculated residual volumetric water content from the van Genuchten equation
[Genuchten_Source]	Byte	1	Indicates if the van Genuchten equation should be fit to experimental or predicted data
[Genuchten_SWCC_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with van Genuchten equation
[Gupta_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Gupta and Larson method
[Gupta_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Gupta and Larson method (True/False)
[hr]	Single	4	(Internal) Constant parameter in Fredlund & Xing equation corresponding to residual suction (kPa)
[jfb]	Single	4	(Internal) Variable parameter in Fredlund Bimodal equation
[kfb]	Single	4	(Internal) Variable parameter in Fredlund Bimodal equation
[lfb]	Single	4	(Internal) Variable parameter in Fredlund Bimodal equation
[mf]	Single	4	(Internal) Variable parameter in Fredlund & Xing equation
[mfb]	Single	4	(Internal) Variable parameter in Fredlund Bimodal equation
[Mualem_AEV]	Single	4	(Internal) Air entry value calculated from the Mualem fit of the soil-water characteristic curve (kPa)
[Mualem_Error]	Single	4	(Internal) Sum of squared differences between Mualem fit and experimental or predicted data
[Mualem_Max_Slope]	Single	4	(Internal) Maximum slope of the Mualem fit of the soil-water characteristic curve (unitless)
[Mualem_Residual_WC]	Single	4	(Internal) Calculated residual volumetric water content from the Mualem equation
[Mualem_SWCC_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with Mualem equation
[mvg]	Single	4	(Internal) Variable parameter in van Genuchten equation
[nb]	Single	4	(Internal) Variable parameter in Burdine equation
[nc]	Single	4	(Internal) Variable parameter in Brooks & Corey equation
[nf]	Single	4	(Internal) Variable parameter in Fredlund &

			Xing equation
[nfb]	Single	4	(Internal) Variable parameter in Fredlund Bimodal equation
[ng]	Single	4	(Internal) Variable parameter in Gardner equation
[nm]	Single	4	(Internal) Variable parameter in Mualem equation
[nvg]	Single	4	(Internal) Variable parameter in van Genuchten equation
[Packing_Porosity]	Single	4	Porosity to use in the packing together of grainsize groups for the prediction of soil-water characteristic curve
[Rawls_AEV]	Single	4	(Internal) Air entry value calculated from the Rawls pedo-transfer function (kPa)
[Rawls_Bubbling_Pressure]	Single	4	(Internal) Brooks and Corey bubbling pressure as estimated from Rawls correlation (kPa)
[Rawls_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Rawls method
[Rawls_Lambda]	Single	4	(Internal) Brooks and Corey Lambda equation parameter as estimated from Rawls correlation
[Rawls_Max_Slope]	Single	4	(Internal) Maximum slope of the Rawls and Brakensiek pedo-transfer function (unitless)
[Rawls_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Rawls method (True/False)
[Scheinost_AEV]	Single	4	(Internal) Air entry value calculated from the Scheinost pedo-transfer function (kPa)
[Scheinost_avg]	Single	4	(Internal) Estimated van Genuchten Alpha parameter
[Scheinost_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Scheinost method
[Scheinost_Max_Slope]	Single	4	(Internal) Maximum slope of the Scheinost pedo-transfer function (unitless)
[Scheinost_mvg]	Single	4	(Internal) Estimated van Genuchten m parameter
[Scheinost_nvg]	Single	4	(Internal) Estimated van Genuchten n parameter
[Scheinost_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Scheinost method (True/False)
[Scheinost_Residual_wc]	Single	4	(Internal) Estimated van Genuchten residual water content
[SWCC_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the soil-water characteristic curve
[SWCC_ID]	GUID	16	(Internal) Record counter
[SWCC_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[SWCC_Soil_Counter]	Long	4	Link to main soil properties table
[SWCC_Specimen_ID]	Text	15	ID of specimen used in test
[SWCC_Technician]	Text	50	Technician responsible for experimental

			results
[SWCC_Test_Date]	Date	8	Date lab test was performed
[SWCC_Test_Method]	Text	255	Test method used to obtain experimental results
[Tyler_AEV]	Single	4	(Internal) Air entry value calculated from the Tyler and Wheatcraft pedo-transfer function (kPa)
[Tyler_Alpha]	Single	4	Empirical constant estimated by Tyler and used to vary the Arya and Paris prediction of water retention
[Tyler_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Tyler and Wheatcraft method
[Tyler_Max_Slope]	Single	4	(Internal) Maximum slope of the Tyler and Wheatcraft pedo-transfer function (unitless)
[Tyler_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Tyler and Wheatcraft method (True/False)
[Vereecken_AEV]	Single	4	(Internal) Air entry value calculated from the Vereecken pedo-transfer function (kPa)
[Vereecken_avg]	Single	4	(Internal) Estimated van Genuchten Alpha parameter
[Vereecken_Error]	Single	4	(Internal) Sum of squared differences between experimental SWCC and predicted SWCC by the Vereecken method
[Vereecken_Max_Slope]	Single	4	(Internal) Maximum slope of the Vereecken pedo-transfer function (unitless)
[Vereecken_mvg]	Single	4	(Internal) Estimated van Genuchten m parameter
[Vereecken_nvg]	Single	4	(Internal) Estimated van Genuchten n parameter
[Vereecken_Predicted]	Boolean	1	(Internal) Indicates if a SWCC has been predicted from the grainsize curve by the Vereecken method (True/False)
[Vereecken_Residual_wc]	Single	4	(Internal) Estimated van Genuchten residual water content
[Wilting_Point]	Single	4	(Internal) Water content corresponding to the wilting point suction for most plants (1500 kPa)

SWCC_Wetting			
Name	FieldType	Length	Description
[SWCCW_ac]	Single	4	(Internal) Variable parameter in Brooks & Corey equation
[SWCCW_af]	Single	4	(Internal) Variable parameter in Fredlund & Xing equation
[SWCCW_avg]	Single	4	(Internal) Variable parameter in van Genuchten equation
[SWCCW_Brooks_Error]	Single	4	(Internal) Sum of squared differences between Brooks & Corey fit and experimental or predicted data
[SWCCW_Brooks_Residual_WC]	Single	4	(Internal) Calculated residual volumetric water content from the Brooks & Corey equation

[SWCCW_Brooks_SWCC_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with Brooks & Corey equation
[SWCCW_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the soil-water characteristic curve
[SWCCW_Fredlund_AEV]	Single	4	(Internal) Suction at which air begins to enter a soil and fill large pores (kPa)
[SWCCW_Fredlund_Error]	Single	4	(Internal) Sum of squared differences between the experimental and Fredlund & Xing fit curves
[SWCCW_Fredlund_Residual_WC]	Single	4	(Internal) Calculated residual volumetric water content from the Fredlund & Xing fit
[SWCCW_Fredlund_SWCC_Fit]	Boolean	1	(Internal) Indicates if the experimental data needs to be fit with the Fredlund & Xing equation (True/False)
[SWCCW_Genuchten_Error]	Single	4	(Internal) Sum of squared differences between van Genuchten fit and experimental or predicted data
[SWCCW_Genuchten_Residual_WC]	Double	8	(Internal) Calculated residual volumetric water content from the van Genuchten equation
[SWCCW_Genuchten_SWCC_Fit]	Boolean	1	(Internal) Indicates if experimental data has been fit with van Genuchten equation
[SWCCW_hr]	Single	4	(Internal) Constant parameter in Fredlund & Xing equation corresponding to residual soil suction (kPa)
[SWCCW_ID]	GUID	16	(Internal) Record counter
[SWCCW_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[SWCCW_mf]	Single	4	(Internal) Variable parameter in Fredlund & Xing equation
[SWCCW_mvg]	Single	4	(Internal) Variable parameter in van Genuchten equation
[SWCCW_nc]	Single	4	(Internal) Variable parameter in Brooks & Corey equation
[SWCCW_nf]	Single	4	(Internal) Variable parameter in Fredlund & Xing equation
[SWCCW_nvg]	Single	4	(Internal) Variable parameter in van Genuchten equation
[SWCCW_Soil_Counter]	Long	4	Link to main soil properties table
[SWCCW_Specimen_ID]	Text	15	ID of specimen used in test
[SWCCW_Technician]	Text	50	Technician responsible for experimental results
[SWCCW_Test_Date]	Date	8	Date lab test was performed
[SWCCW_Test_Method]	Text	255	Test method used to obtain experimental results

Thermal			
Name	FieldType	Length	Description
[at]	Single	4	(Internal) Parameter controlling break point of thermal fit
[mt]	Single	4	(Internal) Parameter controlling curvature of the fit curve
[nt]	Single	4	(Internal) Parameter controlling steepest slope

			of fit curve
[Quartz_Content]	Single	4	Quartz content of soil
[Quartz_Test]	Boolean	1	Indicates if parameters are experimentally determined (True) or estimated (False)
[Soil_Gradation]	Text	8	Gradation of soil
[Soil_State]	Text	10	State of soil
[Thermal_Count]	Byte	1	(Internal) Stores the number of experimentally measured points on the thermal conductivity curve
[Thermal_Data_Source]	Byte	1	Indicates if the equation should be fit to experimental (0) or predicted (1) data
[Thermal_Error]	Single	4	(Internal) R squared difference between experimental and predicted curves
[Thermal_Fit]	Boolean	1	(Internal) Has thermal curve been fit?
[Thermal_Fit_Error]	Single	4	(Internal) R squared difference between experimental or predicted and fit data
[Thermal_Fit_Type]	Byte	1	Type of fit of soil-water characteristic curve used for prediction
[Thermal_ID]	GUID	16	(Internal) Record counter
[Thermal_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Thermal_Predicted]	Boolean	1	(Internal) Indicates whether the prediction needs to be executed (True/False)
[Thermal_Soil_Counter]	Long	4	Link to main soil properties table
[Thermal_Specimen_ID]	Text	15	ID of specimen used in test
[Thermal_Technician]	Text	50	Technician responsible for experimental results
[Thermal_Test_Date]	Date	8	Date lab test was performed
[Thermal_Test_Method]	Text	100	Test method used to obtain experimental results

Unfrozen

Name	FieldType	Length	Description
[afc]	Single	4	(Internal) Parameter controlling break point of frozen cooling fit
[afw]	Single	4	(Internal) Parameter controlling break point of frozen warming fit
[Cooling_Count]	Integer	2	(Internal) Stores the number of experimentally measured points on the cooling unfrozen volumetric water content curve
[Cooling_Data_Source]	Byte	1	Indicates if the equation should be fit to cooling experimental (0) or predicted (1) data
[Cooling_Fit]	Boolean	1	(Internal) Has frozen cooling curve been fit?
[Cooling_Fit_Error]	Single	4	(Internal) R squared difference between cooling experimental or predicted and fit data
[mfc]	Single	4	(Internal) Parameter controlling curvature of the fit cooling curve
[mfw]	Single	4	(Internal) Parameter controlling curvature of the fit warming curve
[nfc]	Single	4	(Internal) Parameter controlling steepest slope

			of fit cooling curve
[nfw]	Single	4	(Internal) Parameter controlling steepest slope of fit warming curve
[Unfrozen_Estimated_Cooling]	Boolean	1	(Internal) Indicates whether the prediction has been executed (True/False) for the cooling curve
[Unfrozen_Estimated_Cooling_Error]	Single	4	(Internal) R squared difference between cooling experimental and predicted results
[Unfrozen_Estimated_Warming]	Boolean	1	(Internal) Indicates whether the prediction has been executed (True/False) for the warming curve
[Unfrozen_Estimated_Warming_Error]	Single	4	(Internal) R squared difference between warming experimental and predicted results
[Unfrozen_Fit_Type]	Byte	1	Type of fit of soil-water characteristic curve to use in prediction
[Unfrozen_ID]	GUID	16	(Internal) Record counter
[Unfrozen_Lab_Notes]	Memo	0	Notes by laboratory technician on test
[Unfrozen_Parameter]	Single	4	Coefficient used to vary the prediction
[Unfrozen_Soil_Counter]	Long	4	Link to main soil properties table
[Unfrozen_Specimen_ID]	Text	15	ID of specimen used in test
[Unfrozen_Technician]	Text	50	Technician responsible for experimental results
[Unfrozen_Test_Date]	Date	8	Date lab test was performed
[Unfrozen_Test_Method]	Text	100	Test method used to obtain experimental results
[Warming_Count]	Integer	2	(Internal) Stores the number of experimentally measured points on the warming unfrozen volumetric water content curve
[Warming_Data_Source]	Byte	1	Indicates if the equation should be fit to warming experimental (0) or predicted (1) data
[Warming_Fit]	Boolean	1	(Internal) Has frozen warming curve been fit?
[Warming_Fit_Error]	Single	4	(Internal) R squared difference between warming experimental or predicted and fit data

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